The Distribution of Landings of British Columbia Salmon in Relation to Size of the Commercial Fishing Fleet, 1967 - 1981. II. Chum Salmon.

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TABLE OF CONTENTS

Page

ABSTRACT iv

INTRODUCTION 1

MATERIALS AND METHODS 1

RESULTS
- GILLNET COMPONENT 3
- SEINE COMPONENT 4
- TROLL COMPONENT 5

DISCUSSION 6

ACKNOWLEDGMENTS 7

LITERATURE CITED 7

TABLES 8

FIGURES 19

APPENDIX A 23

APPENDIX B 39

APPENDIX C 55

ABSTRACT

Beacham, T. D. 1984. The distribution of landings of British Columbia salmon in relation to the size of the commercial fishing fleet, 1967-1981. II. Chum salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1278: 69 p.

The distribution of landings of chum salmon in relation to the size of the commercial fishing fleet was investigated on an annual basis during 1967-1981. An average of 1290 gillnetters accounted for 90% of the total landings in any year. Eighty-seven percent of the vessels participating in the gillnet fishery landed less than 1000 chum salmon annually. The top 50% of the vessels participating in the gillnet fishery accounted for 91% of the total annual landings. An average of 290 purse seiners accounted for 90% of the landings in any year, and 44% of the seiners landed less than 1,000 pieces annually. The top 50% of the seiners accounted for 84% of the total annual landings. An average of 656 trollers accounted for 90% of the total annual landings of chum salmon. About 93% of all vessels participating in the troll fishery for chum salmon landed less than 50 pieces annually. The top 50% of the vessels that landed troll-caught chum salmon accounted for 91% of the total annual landings.

Key words: British Columbia, catch, chum salmon, exploitation, gillnet, seine, troll.

RÉSUMÉ

Beacham, T. D. 1984. The distribution of landings of British Columbia salmon in relation to the size of the commercial fishing fleet, 1967-1981. II. Chum salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1278: 69 p.

On a étudié la distribution annuelle des débarquements de saumon kéta, de 1967 à 1981, en fonction de la taille de la flottille de pêche commerciale. Chaque année, 90 % des débarquements étaient effectués, en moyenne, par 1,290 bateaux de pêche aux filets maillants. De ces bateaux, 87 % ont débarqué moins de 1,000 saumons kétas annuellement et les premiers 50 % se sont appropriés 91 % des prises totales annuelles. Une moyenne de 290 senneurs, dont 44 % ont débarqué moins de 1,000 poissons annuellement, ont capturé 90 % des prises annuelles. Les premiers 50 % de ces senneurs ont pêché 84 % des prises totales annuelles. Une moyenne de 656 bateaux de pêche à la traîne ont capturé 90 % des débarquements totaux annuels de saumon kéta. Environ 93 % de tous les bateaux à la traîne participants ont capturé moins de 50 poissons annuellement et les premiers 50 % se sont appropriés 91 % des prises totales annuelles.

Mots-clés: Colombie-Britannique, prise, saumon kéta, exploitation, filet maillant, senne, ligne traînante.

INTRODUCTION

It is recognized that the British Columbia commercial fishing fleet for salmon is currently too large, given the amount of salmon to be harvested and the efficiency of the fleet to do so. A commission on Pacific fisheries policy suggested that the salmon fleet be reduced to half of its present capacity over a 10-year period (Pearse 1982). This reduction in fleet size was suggested to be accomplished by a buy-back program. In an evaluation of a buy-back program, a committee was established to recommend in part the number of vessels that should be present in the fishery after the buy-back program is completed. The recommendation for the salmon fleet was for 400 seiners, 1467 trollers, and 2208 gillnet plus gillnet/troll combination vessels (Cruickshank et al. 1982). The fleet would then be reduced by 132 seiners (from 532 to 400 200 trollers (from 1667 to 1467), and 300 gillnet plus gillnet/troll combination vessels (from 2508 to 2208) (Cruickshank et al. 1982). However, it is uncertain what the degree of redistribution of the catch would be if the suggested number of vessels were removed from the fleet.

Incomes are distributed non-uniformly among fishermen (Sinclair 1978). Landings of salmon may also be distributed non-uniformly among different vessels participating in the salmon fishery. The present report details the distribution of landings of chum salmon (Oncorhynchus keta) in relation to the size of the commercial fishing fleet and indicates the degree of redistribution of the landings that may be expected when decisions on fleet size are made.

An analysis was conducted in order to determine the distribution of catch in relation to the number of commercial fishing vessels for each species of Pacific salmon and for all species combined on a weight basis. This analysis was conducted for each of the major gear components in the British Columbia salmon fishery (gillnet, seine, and troll). When the distribution of catch of Pacific salmon in relation to the size of the commercial fleet is known, decisions can be made on the level to which the fleet could be reduced. The present report deals with the distribution of landings of chum salmon during 1967-1981 in relation to the number of commercial fishing vessels in British Columbia and it is the second in a series of reports on the distribution of landings of Pacific salmon.

MATERIALS AND METHODS

The information upon which the distribution of landings in relation to the size of the commercial fishing fleet is determined is derived from sales-slips. Wong (1983) has described the procedure used in recording and editing the information contained on the sales-slip. Summarized briefly, sales-slips are generated when the catch is delivered for processing or sold, and information on the commercial fishing vessel (CFV) license number, gear, area, period, and weight or numbers of species caught is recorded.

Sales-slips lacking numbers of salmon landed but containing the weight landed are adjusted for numbers by dividing the weight by the mean weight of the particular species, area, and gear that are applicable.

The analysis in the present study depended upon compiling the annual landings by species for each commercial fishing vessel in the three major gear classifications: purse seiner, gillnetter, and troller. This should be confidential information, so that, as outlined by Wong (1983), original commercial fishing vessel license numbers are converted to different codes by a standard method each year, so that it is not possible to relate catches to a specific vessel without authorization. The analysis for this report used solely the transformed license numbers.

The analysis of the sales-slips revealed that in some instances, there would be only 1 sales-slip for a particular license number in one of the three gear classes in a year. These were assumed to be errors in recording the license number, and were deleted in the subsequent description of the distribution of the catch. The distribution of catch was summarized in two ways, the first being by the number of vessels in a particular gear class, and the second by the percentage of vessels in a particular gear class. The number of vessels that landed salmon in a particular gear class was not constant during 1967-1981, so that both methods were used to describe the catch distribution.

Landings from combination vessels (gillnet and troll gear) were assigned to the appropriate gear that was used to catch the salmon that were sold at the time that the sales-slip was generated. Landings from a combination vessel would thus appear in both the troll and gillnet gear classes as appropriate.

The salmon sales-slip data tapes upon which the present analysis is based were derived from Wong (1983). The number of purse seiners recorded landing chum salmon in 1980 and 1981 was greater than the number of licensed vessels. It was assumed that errors were made in recording the gear of some commercial fishing vessel license numbers so that the maximum number of purse seiners in 1980 and 1981 was set at the number of licenses (532). For the analysis in this report, landings of chum salmon by purse seine vessels were arranged in descending order and landings from the 533rd vessel onwards were deleted. This removed those vessels with the smallest annual landings of chum salmon.

The top 200 vessels in terms of landings for a particular species were recorded annually for trollers and gillnetters during 1967-1981. The top 100 seiners were recorded annually during 1969-1981. When the top vessels were identified in a particular year, it was possible to examine how many were also in the top category in previous and subsequent years. For example, once the top 200 gillnetters for chum salmon had been identified in 1975, it was possible to examine how many of these same vessels were in the top 200 gillnetters for chum salmon in 1973 or 1981. This analysis was conducted in order to determine whether or not some fishermen were successful on a continuing basis.

The analysis of distribution of landings in relation to the number of vessels in each fleet component first proceeded by determining annual landings for each species for each vessel in the three gear categories.

Vessels were then sorted in descending order based upon the size of the landings for each species. Once the total catch and the total number of vessels that participated in the fishery for each species were determined, it was then possible to calculate the proportion of the catch that was taken by different numbers of vessels and also different proportions of the fleet. The number and percentage of vessels that landed different numbers of salmon were also calculated.

RESULTS

GILLNET COMPONENT

The landings of chum salmon by gillnetters have ranged from 0.4 to 3.0 million pieces annually during 1967 to 1981 (Table 1). Landings in excess of 2 million pieces were made in 1970, 1972, and 1973. The gillnet share of the total landings of chum salmon has been about equal to that of the purse seine share, when landings are considered on a coast-wide basis.

The distribution of total landings of chum salmon in relation to the number of vessels participating in the gillnet fishery was examined on an annual basis during 1967-1981 (Appendix A, Tables A1-A15). This 15-year distribution of the landings in relation to the number of vessels in the fishery is summarized in Figure 1. An average of about 1290 vessels accounted for 90% of the total landings in any year. When landings exceeded 2 million pieces, 90% of the landings were accounted for by between 1460 and 1550 vessels (Table 2). The top 943 vessels accounted for an average of 80% of the total landings in any year (Table 2). The increase in landings in moving from 80 to 90% of the total landings was accompanied by an increase in the number of vessels by 37%. In order to account for 100% of the landings as compared with 90%, the number of vessels increased 116% from 1290 to 2783 vessels.

The frequency of total landings per vessel was also investigated on an annual basis. An average of 87% of the vessels participating in the gillnet fishery for chum salmon landed less than 1000 chum salmon annually during 1967-1981 (Table 3). About 4% of the vessels landed more than 2000 chum salmon annually. The poorest 72% of the vessels participating in the gillnet fishery land less than 500 chum salmon each in most years. The top 50% of the vessels participating in the gillnet fishery during 1967-1981 accounted for, on average, 91% of the total annual landings (Table 4). As noted previously, this 90% share of the total gillnet landings of chum salmon was accounted for by 1290 vessels.

The repeatability of success in landing chum salmon was examined by identifying the top 200 gillnetters in each year during 1967-1981 and tallying how many of these 200 were in the top 200 in all other years. The results are illustrated in Table 5. With an average of 2783 vessels in the fishery and under the assumption of a random distribution of the top 200 vessels in all years except the one in which they were the top 200 vessels, one would expect

an average of (200/2783) x 200 = 14 vessels to appear by chance. If 21 or more appear, there is a significant statistical association ($x^2 = 3.84$, $P < 0.05$), which indicates that vessels successful in one year were also successful in previous and successive years. For example, if one examines the top 200 vessels in 1978, there were a significant number of these vessels that were also in the top 200 vessels during 1969-1981 (Table 5). This analysis indicates that successful chum salmon gillnet vessels tend to be successful on a continuing basis.

SEINE COMPONENT

The landings of chum salmon by purse seiners have ranged from 0.4 million pieces in 1971 to 3.2 million pieces in 1973 (Table 1). Purse seiners usually accounted for about 50% of the annual landings after 1971.

The distribution of total landings of chum salmon in relation to the number of purse seiners was examined on an annual basis during 1967-1981 (Appendix B, Tables B1-B15). The distribution of the landings in relation to the number of purse seiners participating in the fishery is summarized in Figure 2. On an average basis between 1967 and 1981, about 290 purse seiners accounted for 90% of the total landings in any year. However, in 1971, when 0.4 million pieces were landed, 173 vessels accounted for 90% of the total landings, and in 1973, when 3.2 million pieces of chum salmon were landed by purse seiners, 293 vessels accounted for 90% of the total (Table 6). An average of 221 vessels accounted for 80% of the total landings in any year. In moving from 80 to 90% of the total landings of chum salmon, the number of vessels increased from 221 to 293. This increase in catch was accounted for by a 33% increase in the number of vessels. In examining the number of vessels that account for 100% of the landings, the number was, on average, 497, an increase of 70% over the number of vessels accounting for 90% of the landings.

The frequency of total landings per vessel was also investigated on an annual basis. About 44% of the purse seiners participating in the chum salmon fishery landed less than 1,000 pieces annually (Table 7). An average of about 12% of the vessels landed in excess of 5,000 pieces annually. The top 50% of the vessels participating in the fishery during 1967-1981 accounted for, on average, 84% of the total annual landings (Table 4). This 80% of the total purse seine landings of chum salmon was previously noted to be accounted for by the top 220 purse seiners.

The annual repeatability of success in landing chum salmon in the purse seine fishery was examined by identifying the top 100 seiners in each year during 1969-1981 and tallying how many of these 100 were in the top 100 in all other years (Table 8). Using an average of 497 vessels in the fishery, one would expect, under the assumption of a random distribution of the top 100 vessels in all years except the one in which they were the top 100 vessels, that an average of (100/497) x 100 = 20 vessels to appear by chance. If 29 or more vessels appear, this indicates that vessels successful in one year (the diagonal of 100s in Table 9) were also successful in the year for which 29 or more vessels are counted ($x^2 = 3.84$, $P < 0.05$). For example, the top 100 seiners for chum salmon in 1969 were also more successful for chum salmon

during 1970-1973 than one would expect by chance (Table 9). There is some evidence to indicate that successful chum salmon purse seine vessels tend to be successful on a short-term basis.

TROLL COMPONENT

The landings of chum salmon by the troll component of the commercial fleet is generally as a by-catch of fishing for other salmon species. Landings of troll-caught chum salmon have usually been less than 30 thousand pieces annually (Table 1). Landings in excess of 60 thousand pieces were recorded in 1978 and 1980.

The distribution of total landings of chum salmon in relation to the number of vessels that used troll gear to land chum salmon was examined on an annual basis during 1967-1981 (Appendix C, Tables C1-C15). The distribution of landings of chum salmon in relation to the number of vessels using troll gear that participated in the fishery is summarized in Fig. 3. On an average basis between 1967 and 1981, about 656 trollers accounted for 90% of the landings in any year (Table 9). Trollers had the greatest landing of chum salmon in any year during 1967-1981 in 1980, and in that year, 665 vessels accounted for 90% of the total landings. On an average basis between 1967 and 1981, the top 403 vessels accounted for 80% of the landings in any year. In increasing from 80 to 90% of the total troll-caught landings of chum salmon, the average number of vessels that accounted for the catch increased from 403 to 656, an increase of 63%. An average of 1476 vessels accounted for 100% of troll-caught chum salmon, an increase of 125% over the number of vessels accounting for 90% of the landings.

The frequency of total landings per vessel was also investigated on an annual basis during 1967-1981. An average of 41 vessels landed more than 100 chum salmon annually (Table 10). Of the vessels that used troll gear to land chum salmon, over 90% of these vessels landed less than 50 troll-caught chum salmon annually. The top 50% of the vessels that landed troll-caught chum salmon during 1967-1981 accounted for, on average, 91% of the total annual landings (Table 4).

The repeatability of success in landing chum salmon in the troll fishery was examined by identifying the top 200 vessels in each year during 1967-1981, and tallying how many of these 200 were in the top 200 in all other years (Table 11). Using an average of 1476 vessels in the fishery, one would expect, under the assumption of a random distribution of the top 200 vessels in all years except the one in which they were the top 200 vessels, that an average of (200 x 200/1476) = 27 vessels to appear by chance. If 37 or more vessels appear, this indicates that the vessels successful in one year (the diagonal of 200s in Table 11) were also successful in the year in which 37 or more vessels were counted ($x^2 = 3.84$, $P < 0.05$). For example, the top 200 trollers in 1978 were also more successful for chum salmon during 1977 to 1981 than one would expect by chance alone (Table 11). This analysis suggests that successful troll fishermen for chum salmon tend to be successful on a short-term basis.

DISCUSSION

The number of vessels accounting for 90% of the harvest of British Columbia chum salmon under a similar management policy as was instituted during 1967-1981 was found to be about 1290 gillnet vessels, 290 purse seine vessels, and 660 trollers. However, the catch of chum salmon by trollers is largely by-catch, and trollers account for less than 2% of the total landings. Reducing the size of the commercial net fleet to the previously noted levels would not significantly reduce the overall landings of chum salmon nor the exploitation rates on the species. With less competition among vessels of each gear class under a reduced fleet size, the exploitation rate of an average vessel could increase to the extent that overall exploitation rates on chum salmon stocks could increase. Exploitation rates must necessarily continue to be regulated by restrictions on fishing time and locations.

The number of vessels of each gear class that the present analysis indicates would be sufficient to harvest British Columbia chum salmon is less than the recommendations of a British Columbia fleet rationalization committee of 2208 gillnetters, 400 seiners, and 1467 trollers (Cruikshank et al. 1982). The present analysis suggests that the number of seiners could be reduced by 45% (from 532 to 290) and gillnetters and combination gillnet/troll vessels by 48% (from 2508 to 1290) and the landings of chum salmon would not be significantly reduced. It is assumed that the least effective vessels would be removed from the fishery. The present analysis deals only with chum salmon landings, but the results for the other species are similar. For example, an average of 1320 gillnetters and 305 seiners accounted for 90% of the landings for each gear type of pink salmon in British Columbia during 1967-1981 (Beacham unpublished data).

Reduction of fleet size to the levels suggested by the fleet rationalization committee (Cruickshank et al. 1982) were projected to result in rapid rises in income to the vessels remaining in the commercial fleet. The present analysis for chum salmon suggests that if the least efficient vessels are removed from the fleet, mean landings of chum salmon per vessel will not increase and thus mean gross income per vessel remaining in the fleet will not increase, as long as total catches do not increase and prices remain stable.

The present report outlines the number of vessels necessary to harvest British Columbia chum salmon in the net fleet if current management practices are continued and gear distributions of catch are maintained. It does not consider the social implications of reduction of fleet size and these should be considered in the establishment of targets for a reduced size of the commercial salmon fleet in British Columbia.

ACKNOWLEDGMENTS

Mr. Fred Wong made available the data upon which the distribution of landings of salmon in relation to fleet size was determined. Mr. Bruce Bernard designed the computer software for the graphics in this report. Mr. Bernard's assistance in this project was invaluable, and the study could not have been conducted in its present form without his considerable talents.

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Table 1. Commercial landings (pieces) of chum salmon in British Columbia, 1967-1981.

Year	Gillnet	Seine	Troll	Total
1967	692010	409380	3660	1105050
1968	1856970	1230390	7290	3094650
1969	855710	449570	5160	1310440
1970	2364310	1280290	34770	3679370
1971	843780	405400	13790	1252970
1972	2989540	3075570	10850	6075960
1973	3024830	3176890	23310	6225030
1974	1387910	797090	16780	2201780
1975	597540	534190	15430	1147160
1976	831080	1054270	15690	1901040
1977	579300	486970	21890	1088160
1978	1240340	1677390	60950	2978680
1979	398700	427320	40290	866310
1980	1814550	1913880	67600	3796030
1981	587850	507310	27780	1122940

Table 2. Number of gillnetters accounting for varying percentages of the total gillnet landings of chum salmon, 1967-1981.

Percent of total landings	Year															
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1967-1981
10	30	40	46	56	38	58	68	53	35	57	43	55	34	57	36	47
20	70	95	111	130	88	138	154	131	105	145	103	129	79	136	85	113
30	119	164	192	218	147	239	256	223	196	252	178	220	135	223	145	194
40	176	248	290	322	216	361	374	331	308	382	265	328	201	347	217	291
50	245	351	409	446	298	504	506	459	442	539	368	456	279	477	306	406
60	334	481	558	600	396	674	660	609	602	724	491	611	373	628	417	544
70	452	648	752	795	521	879	849	791	803	952	640	802	488	809	552	716
80	634	872	1,017	1,062	690	1,148	1,093	1,031	1,071	1,236	831	1,052	636	1,043	728	943
90	982	1,231	1,435	1,475	971	1,547	1,464	1,387	1,478	1,627	1,102	1,426	852	1,382	989	1,290
100	2,811	2,922	3,232	3,460	3,073	3,369	2,956	2,878	2,800	2,740	2,493	2,622	1,719	2,684	2,002	2,783

Table 3. Frequencies (and percentage) of vessels landing chum salmon in British Columbia by gillnets, 1967-1981.

Catch Interval (pieces)	Year 1967	1968	1969	1970	1971	1972	1973	1974
0-500	2421 (86.1)	2008 (68.7)	2661 (82.3)	2174 (62.8)	2480 (80.7)	1783 (52.9)	1390 (47.0)	1871 (65.0)
501 -1000	230 (8.2)	448 (15.3)	406 (12.6)	523 (15.1)	329 (10.7)	506 (15.0)	471 (15.9)	563 (19.6)
1001-1500	109 (3.9)	208 (7.1)	116 (3.6)	304 (8.8)	171 (5.6)	363 (10.8)	331 (11.2)	278 (9.7)
1501-2000	43 (1.5)	114 (3.9)	37 (1.1)	179 (5.2)	66 (2.1)	264 (7.8)	243 (8.2)	116 (4.0)
2001-2500	6 (0.2)	66 (2.3)	8 (0.2)	121 (3.5)	20 (0.7)	192 (5.7)	223 (7.5)	26 (0.9)
2501-3000	0 (0.0)	39 (1.3)	2 (0.1)	87 (2.5)	5 (0.2)	96 (2.8)	134 (4.5)	15 (0.5)
3001-3500	0 (0.0)	20 (0.7)	0 (0.0)	39 (1.1)	1 (0.0)	58 (1.7)	78 (2.6)	4 (0.1)
3500+	2 (0.1)	19 (0.7)	0 (0.0)	33 (0.9)	1 (0.0)	107 (3.2)	86 (2.9)	5 (0.2)
Total	2811	2922	3232	3460	3073	3369	2956	2878

Catch Interval (pieces)	Year 1975	1976	1977	1978	1979	1980	1981	1967-1981
0-500	2517 (89.9)	2241 (81.8)	2113 (84.8)	1718 (65.5)	1498 (87.1)	1551 (57.8)	1627 (81.3)	2003 (72.0)
501 -1000	243 (8.7)	423 (15.4)	327 (13.1)	553 (21.1)	197 (11.5)	577 (21.5)	276 (13.8)	405 (14.6)
1001-1500	20 (0.7)	63 (2.3)	43 (1.7)	235 (9.0)	23 (1.3)	353 (13.2)	85 (4.2)	180 (6.5)
1501-2000	14 (0.5)	11 (0.4)	8 (0.3)	81 (3.1)	1 (0.0)	122 (4.5)	10 (0.5)	87 (3.1)
2001-2500	4 (0.1)	1 (0.0)	1 (0.0)	25 (1.0)	0 (0.0)	49 (1.8)	3 (0.1)	50 (1.8)
2501-3000	1 (0.0)	0 (0.0)	0 (0.0)	6 (0.2)	0 (0.0)	22 (0.8)	0 (0.0)	27 (1.0)
3001-3500	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.2)	0 (0.0)	5 (0.2)	0 (0.0)	14 (0.5)
3500+	1 (0.0)	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (0.2)	1 (0.0)	17 (0.6)
Total	2800	2740	2493	2622	1719	2684	2002	2783

Table 4. Percentage of total landings of chum salmon that the top 50% of the vessels participating in the fishery for each gear accounted for.

Year	Gillnet	Seine	Troll
1967	96	95	82
1968	94	90	92
1969	92	88	89
1970	93	92	92
1971	97	95	90
1972	92	90	70
1973	90	81	93
1974	91	82	94
1975	88	82	94
1976	84	74	94
1977	93	83	90
1978	88	73	93
1979	90	83	91
1980	89	74	95
1981	90	83	92
Mean	91	84	91

Table 5. A measure of the repeatability of success of landing chum salmon by gillnetters. The top 200 gillnetters in terms of chum salmon landings were identified each year (diagonal in table). The number of times that those 200 vessels were in the top 200 in previous and subsequent years is recorded by column. For example, of the top 200 gillnetters in 1973, 59 of those 200 were in the top 200 in 1969 and 43 in the top 200 in 1978. Twenty-one or more vessels in each year is indicative of a significant statistical association.

	Year														
Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1967	200	70	33	37	42	18	27	15	12	16	14	11	12	9	8
1968	70	200	65	59	45	33	42	28	17	17	17	18	14	15	7
1969	33	65	200	84	51	52	59	31	27	23	22	27	14	17	14
1970	37	59	84	200	63	45	54	31	20	30	14	22	22	14	18
1971	42	46	51	63	200	38	57	38	19	23	27	23	17	11	9
1972	18	33	52	45	38	200	74	45	32	36	23	31	19	29	18
1973	27	42	59	54	57	74	200	64	31	47	38	43	32	35	21
1974	15	28	31	31	38	45	64	200	51	53	38	38	37	31	26
1975	12	17	27	20	19	32	31	51	200	44	42	32	24	28	23
1976	16	17	23	30	23	36	47	53	44	200	29	36	48	28	43
1977	14	17	22	14	27	23	38	38	42	29	200	46	38	43	21
1978	11	18	27	22	23	31	43	38	32	36	46	200	46	56	38
1979	12	14	14	22	17	19	32	37	24	48	38	46	200	61	77
1980	9	15	17	14	11	29	35	31	28	28	43	56	61	200	56
1981	8	7	14	18	9	18	21	26	23	43	21	38	77	56	200

Table 6. Number of purse seiners accounting for varying percentages of the total purse seine landings of chum salmon, 1967-1981.

Percent of total landings	Year															
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1967-1981
10	7	13	14	11	4	11	15	9	8	19	11	19	12	18	14	12
20	16	30	29	26	10	25	35	24	23	43	24	44	28	41	31	29
30	27	50	47	44	18	42	57	42	44	71	42	73	47	69	53	48
40	40	72	67	65	27	62	83	65	70	103	64	105	71	102	78	72
50	56	97	89	90	40	88	112	92	101	138	92	143	101	141	107	99
60	76	125	114	121	56	118	145	127	138	179	126	186	138	186	143	132
70	102	158	146	157	75	155	185	170	183	226	168	237	181	240	186	171
80	135	198	186	201	108	201	233	226	236	283	221	296	236	306	244	221
90	187	250	241	261	173	264	293	301	308	352	295	368	311	392	328	288
100	476	497	413	555	471	527	476	485	493	496	490	506	513	532	532	497

Table 7. Frequencies (and percentage) of vessels landing chum salmon in British Columbia by purse seines, 1967-1981.

Catch Interval (pieces)	Year 1967	1968	1969	1970	1971	1972	1973	1974
1-1000	336 (70.6)	191 (38.4)	237 (57.4)	228 (41.1)	366 (77.7)	161 (30.6)	77 (16.2)	213 (43.9)
1001-2000	76 (16.0)	64 (12.9)	102 (24.7)	89 (16.0)	41 (8.7)	28 (5.3)	30 (6.3)	150 (30.9)
2001-3000	29 (6.1)	64 (12.9)	49 (11.9)	64 (11.5)	27 (5.7)	35 (6.6)	27 (5.7)	48 (9.9)
3001-4000	17 (3.6)	53 (10.7)	13 (3.1)	66 (11.9)	14 (3.0)	32 (6.1)	32 (6.7)	37 (7.6)
4001-5000	10 (2.1)	53 (10.7)	4 (1.0)	28 (5.0)	3 (0.6)	44 (8.3)	40 (8.4)	20 (4.1)
5001-6000	4 (0.8)	32 (6.4)	7 (1.7)	24 (4.3)	10 (2.1)	39 (7.4)	32 (6.7)	8 (1.6)
6001-7000	3 (0.6)	17 (3.4)	1 (0.2)	21 (3.4)	5 (1.1)	20 (3.8)	42 (8.8)	2 (0.4)
7001-8000	1 (0.2)	13 (2.6)	0 (0.0)	10 (1.8)	1 (0.2)	23 (4.4)	37 (7.8)	1 (0.2)
8001-9000	0 (0.0)	4 (0.8)	0 (0.0)	10 (1.8)	1 (0.2)	25 (4.7)	23 (4.8)	2 (0.4)
9000+	0 (0.0)	6 (1.2)	0 (0.0)	15 (2.7)	3 (0.6)	120 (22.8)	136 (28.6)	4 (0.8)
Total	476	497	413	555	471	527	476	485

Catch Interval (pieces)	Year 1975	1976	1977	1978	1979	1980	1981	1967-1981
1-1000	287 (58.2)	97 (19.6)	315 (64.3)	48 (9.5)	336 (65.5)	52 (9.8)	346 (65.0)	220 (44.3)
1001-2000	146 (29.6)	170 (34.3)	110 (22.4)	91 (18.0)	102 (19.9)	117 (22.0)	120 (22.6)	96 (19.4)
2001-3000	40 (8.1)	114 (23.0)	36 (7.3)	124 (24.5)	32 (6.2)	122 (22.9)	46 (8.6)	58 (11.7)
3001-4000	11 (2.2)	73 (14.7)	17 (3.5)	94 (18.6)	11 (2.1)	79 (14.8)	17 (3.2)	38 (7.7)
4001-5000	3 (0.6)	30 (6.0)	10 (2.0)	55 (10.9)	2 (0.4)	53 (10.0)	2 (0.4)	24 (4.8)
5001-6000	3 (0.6)	8 (1.6)	2 (0.4)	47 (9.3)	0 (0.0)	45 (8.5)	0 (0.0)	17 (3.4)
6001-7000	1 (0.2)	1 (0.2)	0 (0.0)	21 (4.2)	0 (0.0)	21 (3.9)	1 (0.2)	10 (2.0)
7001-8000	1 (0.2)	2 (0.4)	0 (0.0)	12 (2.4)	0 (0.0)	17 (3.2)	0 (0.0)	8 (1.6)
8001-9000	0 (0.0)	1 (0.2)	0 (0.0)	8 (1.6)	0 (0.0)	12 (2.3)	0 (0.0)	6 (1.2)
9000+	1 (0.2)	0 (0.0)	0 (0.0)	6 (1.2)	0 (0.0)	14 (2.6)	0 (0.0)	20 (4.0)
Total	493	496	490	506	513	532	532	497

Table 8. A measure of the repeatability of success of landing chum salmon by purse seiners. The top 100 seiners in terms of chum salmon landings were identified in each year (diagonal in table). The number of times that those 100 vessels were in the top 100 in previous and subsequent years is recorded by column. For example, of the top 100 seiners in 1973, 39 of those 100 were in the top 100 in 1969 and 25 were in the top 200 in 1976. Twenty-nine or more vessels in each year is indicative of a significant statistical association.

	Year												
Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1969	100	36	29	32	39	28	29	25	24	13	20	8	17
1970	35	100	45	33	28	29	22	20	25	12	12	5	8
1971	29	45	100	28	30	43	23	13	35	13	20	5	13
1972	32	33	28	100	40	34	23	26	17	18	21	13	24
1973	39	28	30	40	100	33	36	25	24	18	21	8	16
1974	28	29	43	34	33	100	34	23	35	17	30	13	18
1975	29	22	23	23	36	34	100	43	35	39	32	12	21
1976	25	20	13	26	25	23	43	100	23	38	27	21	26
1977	24	25	35	17	24	35	35	23	100	27	31	17	19
1978	13	12	13	18	18	17	39	38	27	100	28	33	25
1979	20	12	20	21	21	30	32	27	31	28	100	29	37
1980	8	5	5	13	8	13	12	21	17	33	29	100	34
1981	17	8	13	24	16	18	21	26	19	25	37	34	100

Table 9. Number of trollers accounting for varying percentages of the total troll-caught landings of chum salmon, 1967-1981.

Percent of total landings	Year															
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1967-1981
10	7	3	1	8	3	4	3	2	5	2	7	18	12	9	7	6
20	23	11	3	22	8	15	9	4	16	5	17	44	40	21	29	18
30	51	23	8	50	23	34	17	6	31	14	44	81	84	38	65	38
40	91	42	21	92	38	65	26	10	59	26	89	130	141	63	112	67
50	144	72	48	154	108	111	41	16	100	42	154	194	218	99	175	112
60	213	116	94	240	181	174	72	26	160	66	242	284	320	156	254	173
70	301	183	166	361	282	263	136	49	247	108	365	406	459	243	365	262
80	423	298	279	548	427	393	278	135	379	206	544	581	659	379	521	403
90	597	522	469	876	660	622	573	363	611	426	835	867	978	665	776	656
100	930	1,182	888	1,985	1,342	1,255	1,491	1,082	1,321	1,217	1,715	2,005	2,018	2,052	1,653	1,476

Table 10. Frequencies (and percentage) of vessels landing chum salmon in British Columbia by troll gear, 1967-1981.

Catch Interval (pieces)	Year 1967	1968	1969	1970	1971	1972	1973	1974
1- 50	928 (99.8)	1133 (95.9)	878 (98.9)	1837 (92.5)	1316 (98.1)	1228 (97.8)	1410 (94.6)	1038 (95.9)
51-100	2 (0.2)	28 (2.4)	7 (0.8)	99 (5.0)	14 (1.0)	17 (1.4)	39 (2.6)	16 (1.5)
101-150	0 (0.0)	13 (1.1)	0 (0.0)	24 (1.2)	3 (0.2)	7 (0.6)	9 (0.6)	7 (0.6)
151-200	0 (0.0)	2 (0.2)	0 (0.0)	8 (0.4)	2 (0.1)	0 (0.0)	5 (0.3)	4 (0.4)
201-250	0 (0.0)	1 (0.1)	2 (0.2)	2 (0.1)	1 (0.1)	1 (0.1)	6 (0.4)	2 (0.2)
251-300	0 (0.0)	3 (0.3)	0 (0.0)	3 (0.2)	1 (0.1)	1 (0.1)	8 (0.5)	5 (0.2)
300+	0 (0.0)	3 (0.2)	1 (0.1)	12 (0.6)	5 (0.4)	1 (0.1)	13 (0.9)	10 (0.9)
Total	930	1182	888	1985	1342	1255	1491	1082

Catch Interval (pieces)	Year 1975	1976	1977	1978	1979	1980	1981	1967-1981
1- 50	1273 (96.4)	1147 (94.2)	1653 (96.4)	1664 (83.0)	1824 (90.4)	1747 (85.1)	1535 (92.9)	1374 (93.1)
51-100	24 (1.8)	40 (3.3)	43 (2.5)	188 (9.4)	144 (7.1)	164 (8.0)	93 (5.6)	61 (4.1)
101-150	16 (1.2)	18 (1.5)	6 (0.3)	81 (4.0)	27 (1.3)	45 (2.2)	16 (1.0)	18 (1.2)
151-200	4 (0.3)	2 (0.2)	3 (0.2)	32 (1.6)	13 (0.6)	26 (1.3)	1 (0.1)	7 (0.5)
201-250	1 (0.1)	4 (0.3)	4 (0.2)	14 (0.7)	1 (0.0)	13 (0.6)	2 (0.1)	4 (0.3)
251-300	2 (0.2)	2 (0.2)	0 (0.0)	13 (0.7)	3 (0.1)	17 (0.8)	1 (0.1)	4 (0.3)
300+	1 (0.1)	4 (0.3)	6 (0.3)	13 (0.7)	6 (0.3)	40 (1.9)	5 (0.3)	8 (0.5)
Total	1321	1217	1715	2005	2018	2052	1653	1476

Table 11. A measure of the repeatability of success of landing chum salmon by trollers. The top 200 trollers in terms of chum salmon landings were identified each year (diagonal in table). The number of times that those 200 vessels were in the top 200 in previous and subsequent years is recorded by column. For example, of the top 200 trollers in 1977, 27 of those 200 were in the top 200 in 1974 and 25 in the top 200 in 1981 or more vessels in each year is indicative of a significant statistical association.

	Year														
Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1967	200	26	26	30	19	24	7	21	10	19	14	9	15	11	14
1968	26	200	22	26	20	17	9	8	13	12	11	4	9	7	6
1969	26	22	200	53	42	20	17	10	22	14	11	16	18	14	14
1970	30	26	53	200	52	29	26	17	18	17	13	19	14	14	10
1971	19	20	42	52	200	38	20	25	34	22	22	21	19	19	18
1972	24	17	20	29	38	200	32	35	26	19	22	28	24	15	7
1973	7	9	17	26	20	32	200	33	31	15	21	16	21	11	10
1974	21	8	10	17	25	35	33	200	28	30	27	27	16	12	19
1975	10	13	22	18	34	26	31	28	200	33	26	30	21	24	17
1976	19	12	14	17	22	19	15	30	33	200	27	22	20	22	18
1977	14	11	11	13	22	22	21	27	26	27	200	51	35	30	25
1978	9	4	16	19	21	28	16	27	30	22	51	200	45	39	38
1979	15	9	18	14	19	24	21	16	21	20	35	45	200	59	44
1980	11	7	14	14	19	15	11	12	24	22	30	39	59	200	54
1981	14	6	14	10	18	7	10	19	17	18	25	38	44	54	200

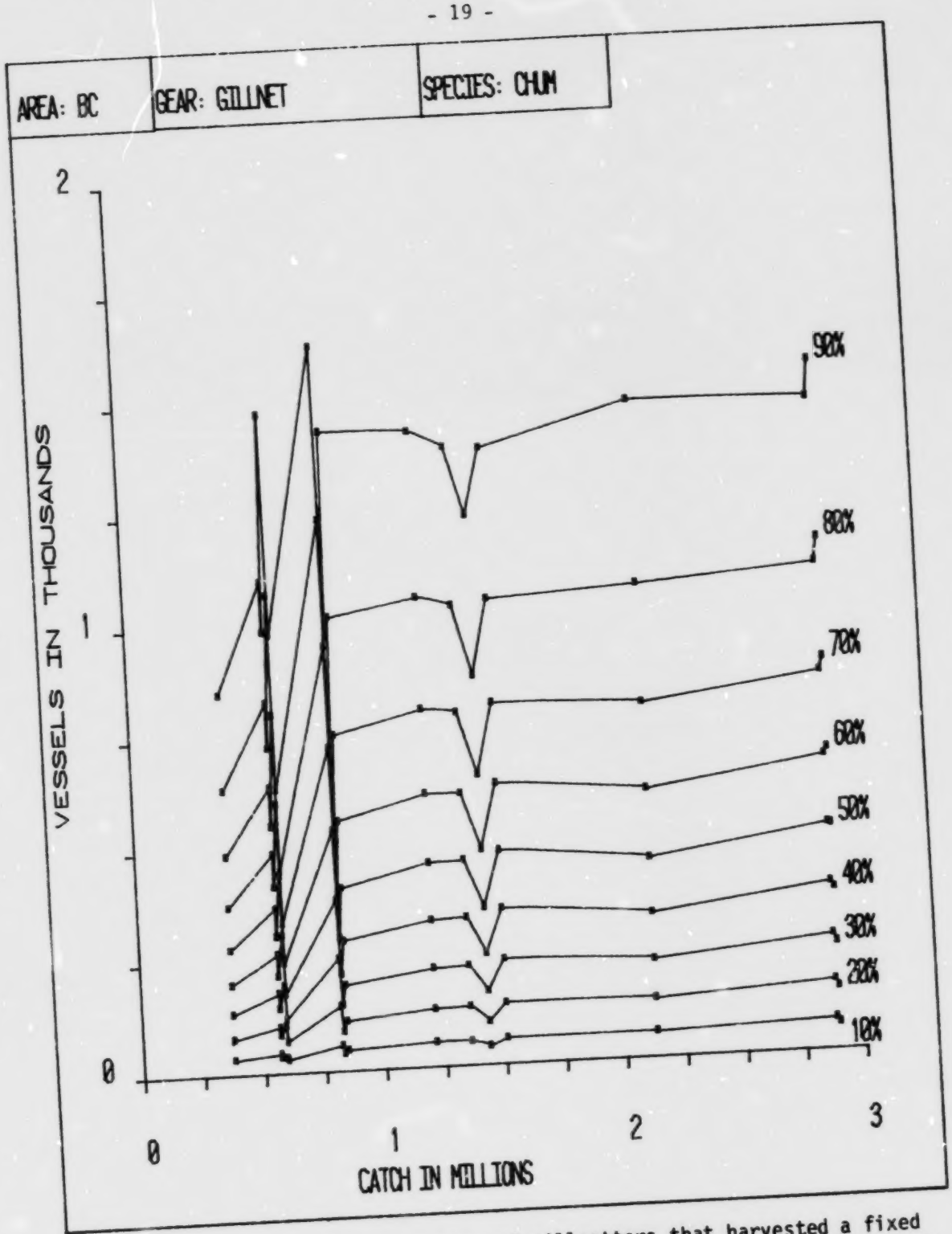

Fig. 1. Contour plots for the number of gillnetters that harvested a fixed percentage of the total annual catch of chum salmon by gillnetters versus the size of the annual catch during 1967-1981.

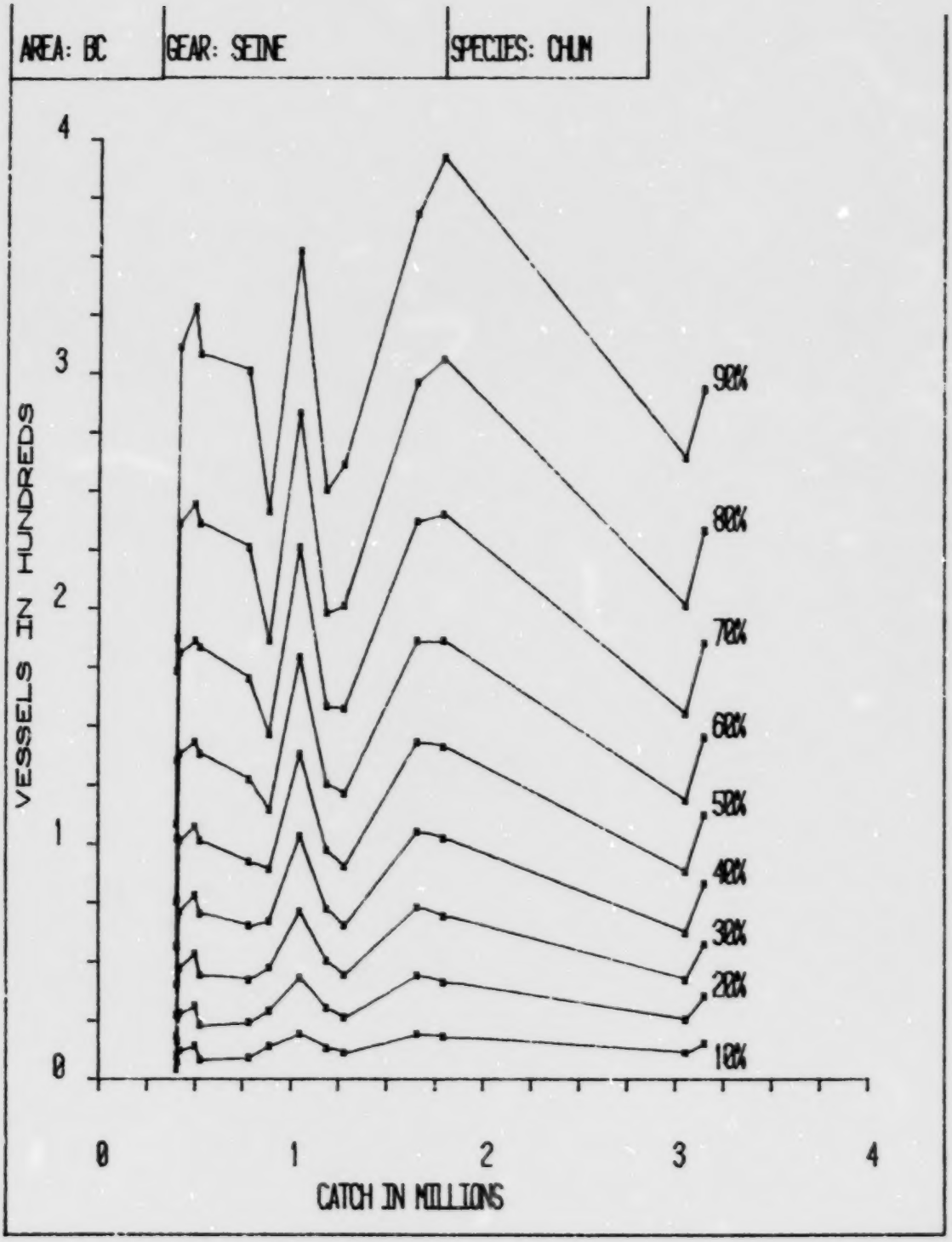

Fig. 2. Contour plots for the number of seiners that harvested a fixed percentage of the total annual catch of chum salmon by seiners versus the size of the annual catch during 1967-1981.

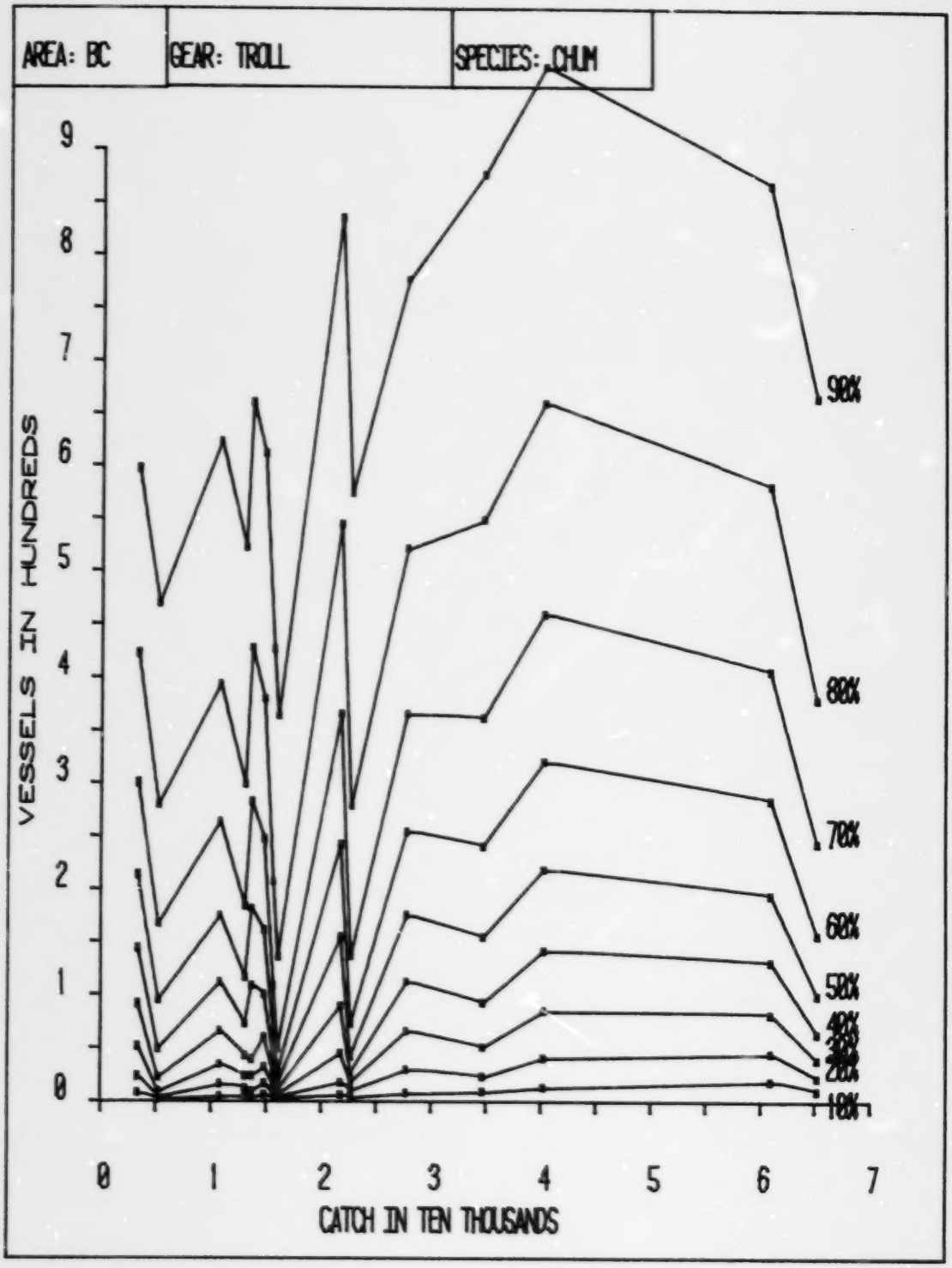

Fig. 3. Contour plots for the number of trollers that harvested a fixed percentage of the total annual catch of chum salmon by trollers versus the size of the annual catch during 1967-1981.

APPENDIX A

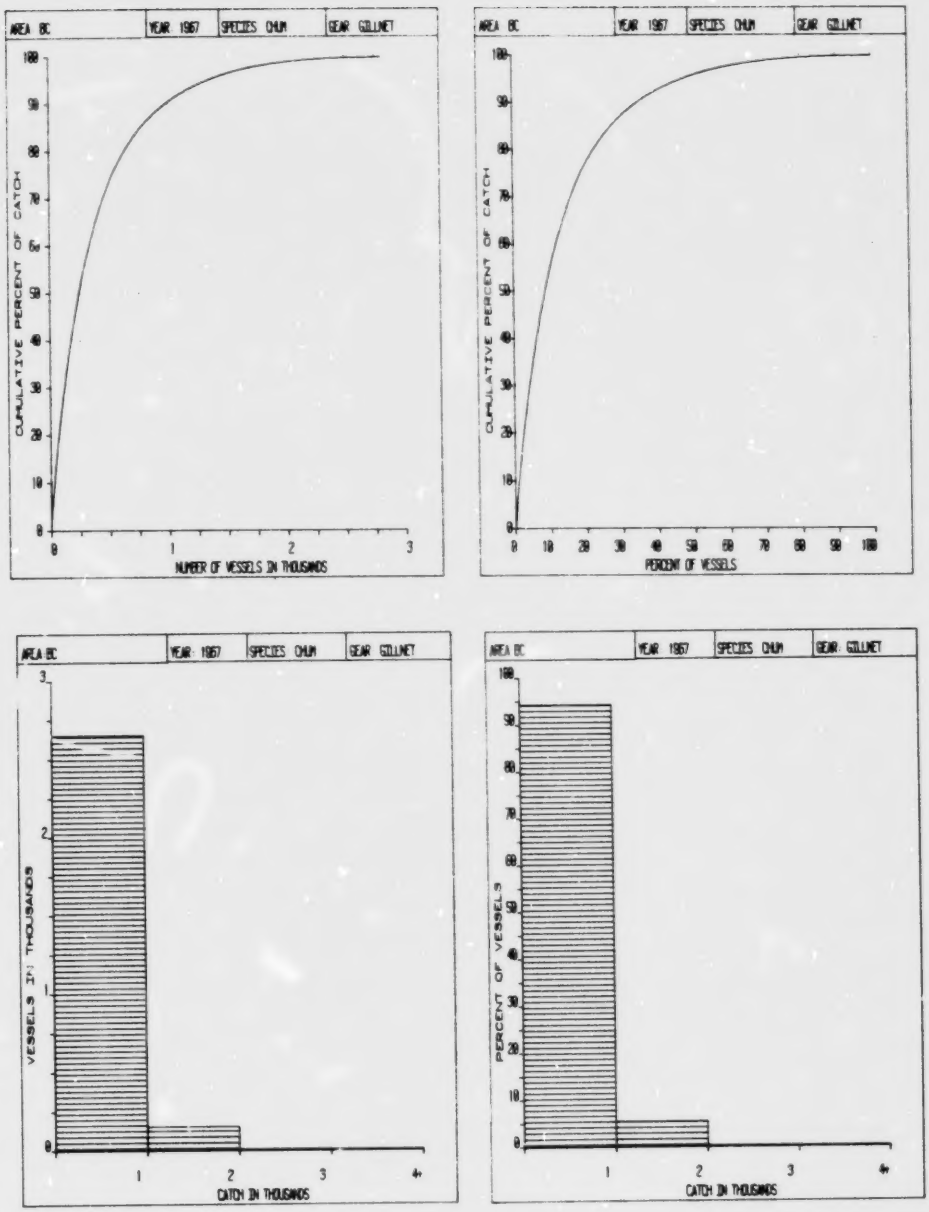

Fig. A1. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1967.

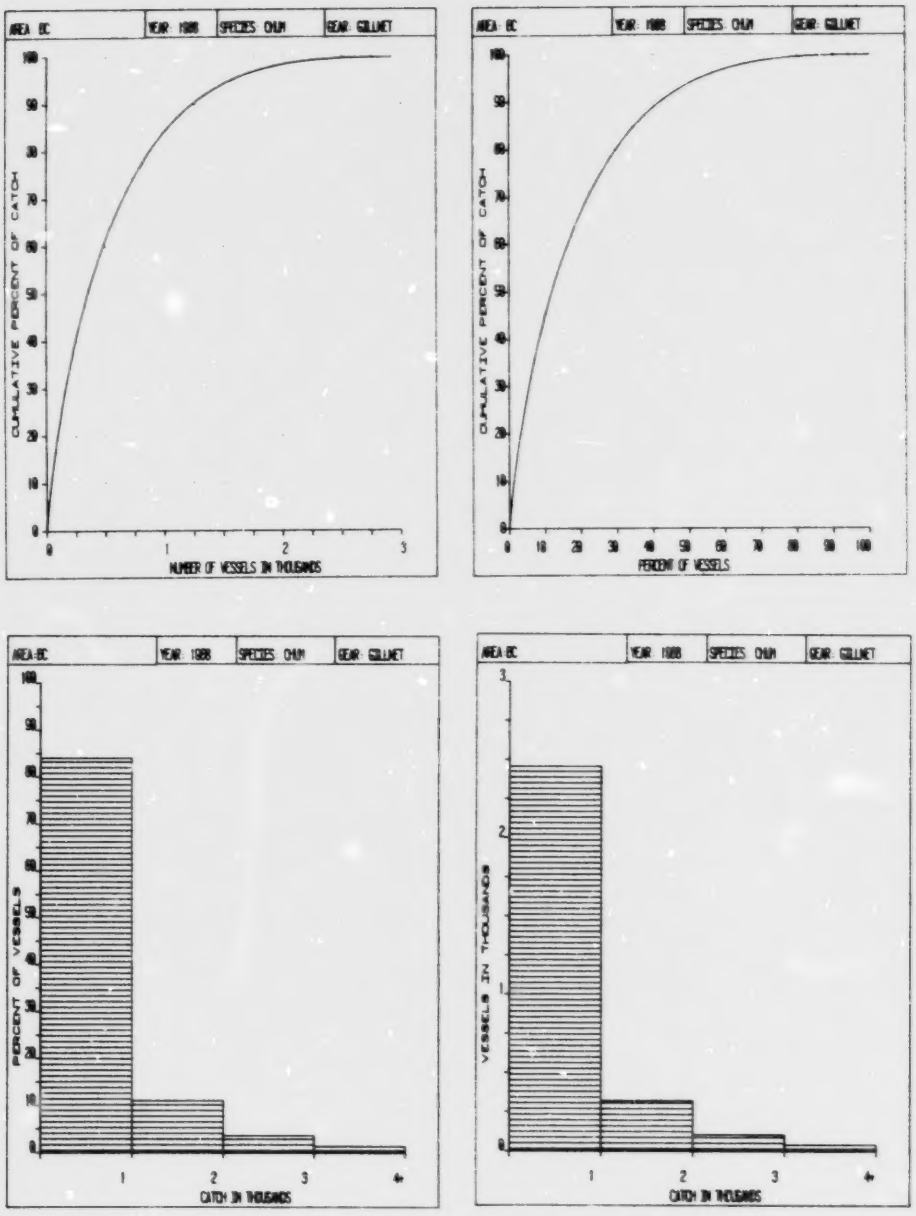

Fig. A2. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1968.

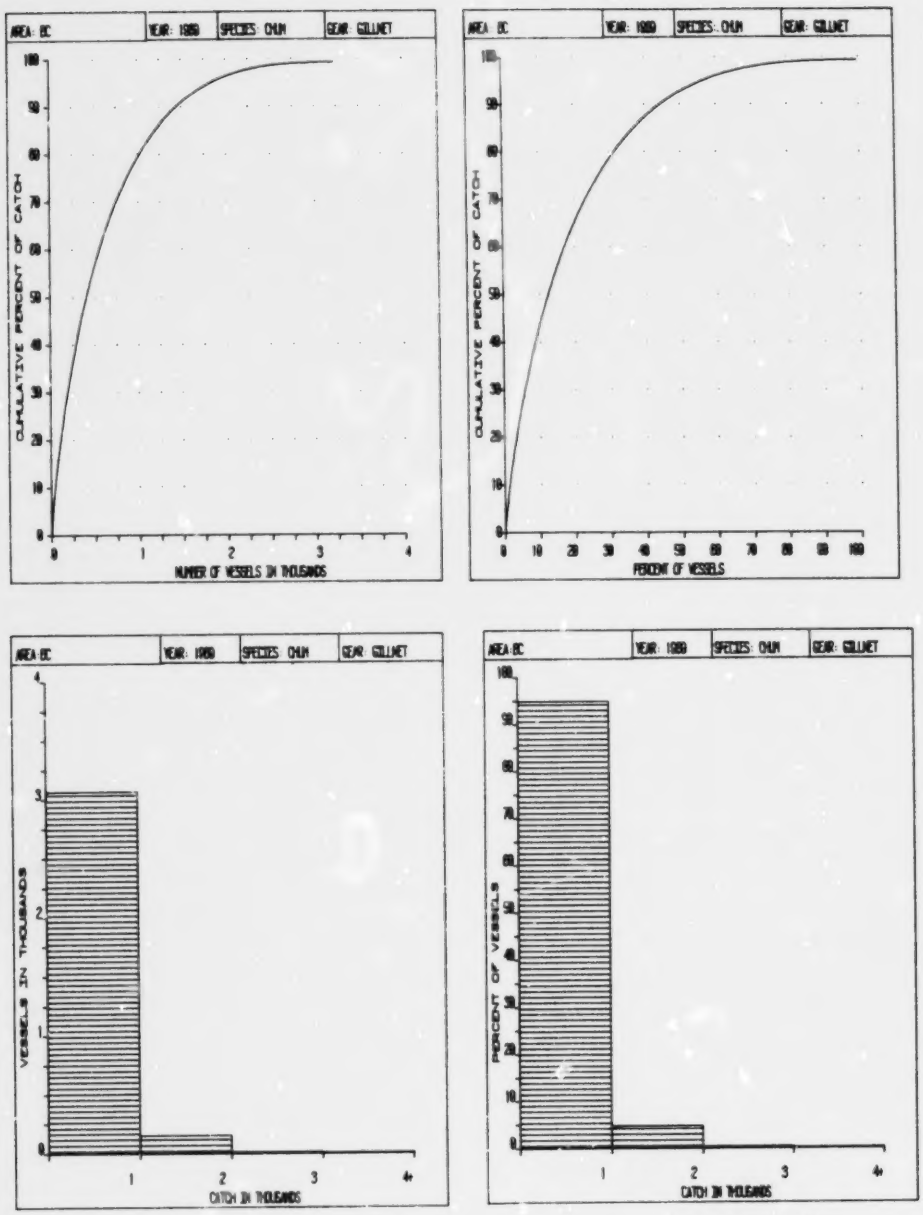

Fig. A3. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1969.

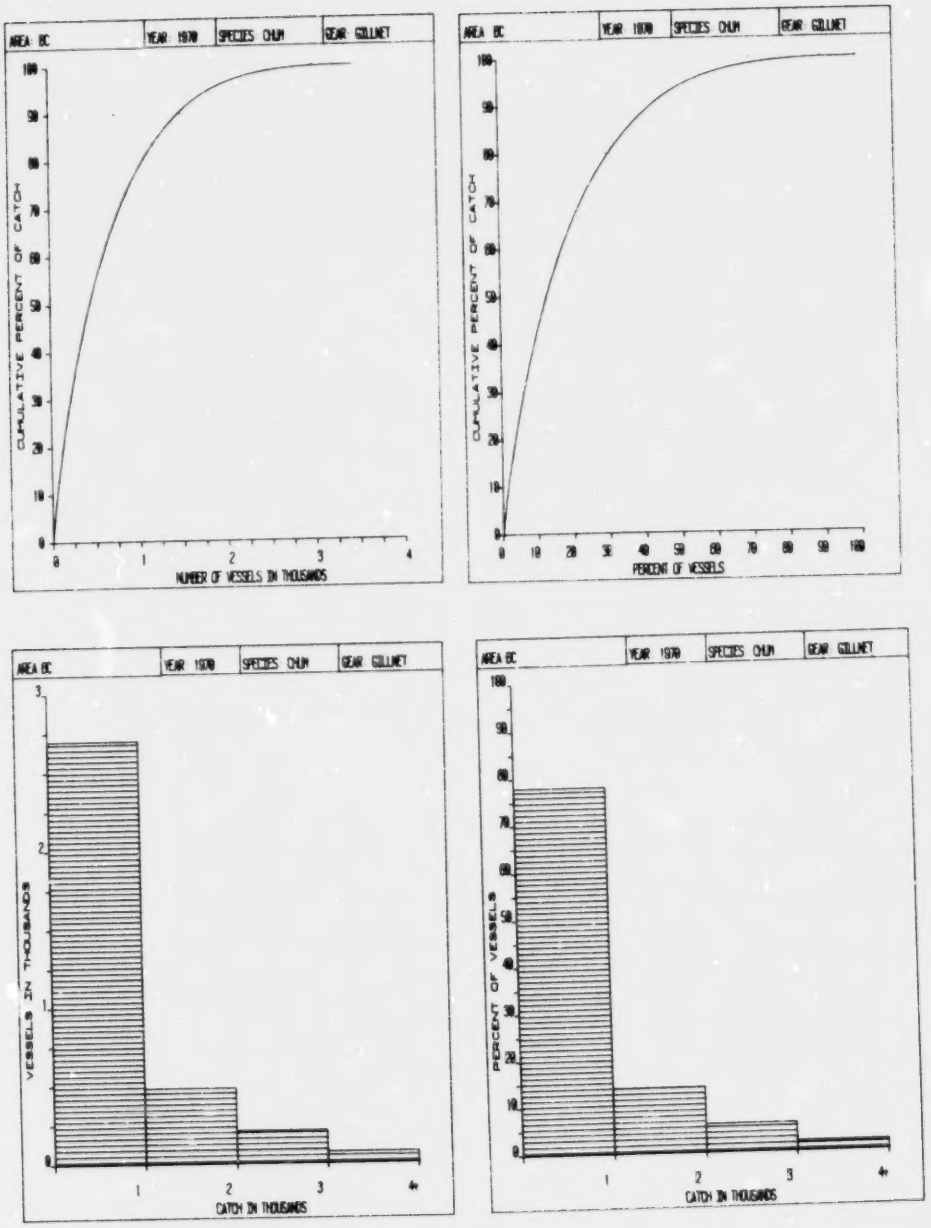

Fig. A4. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1970.

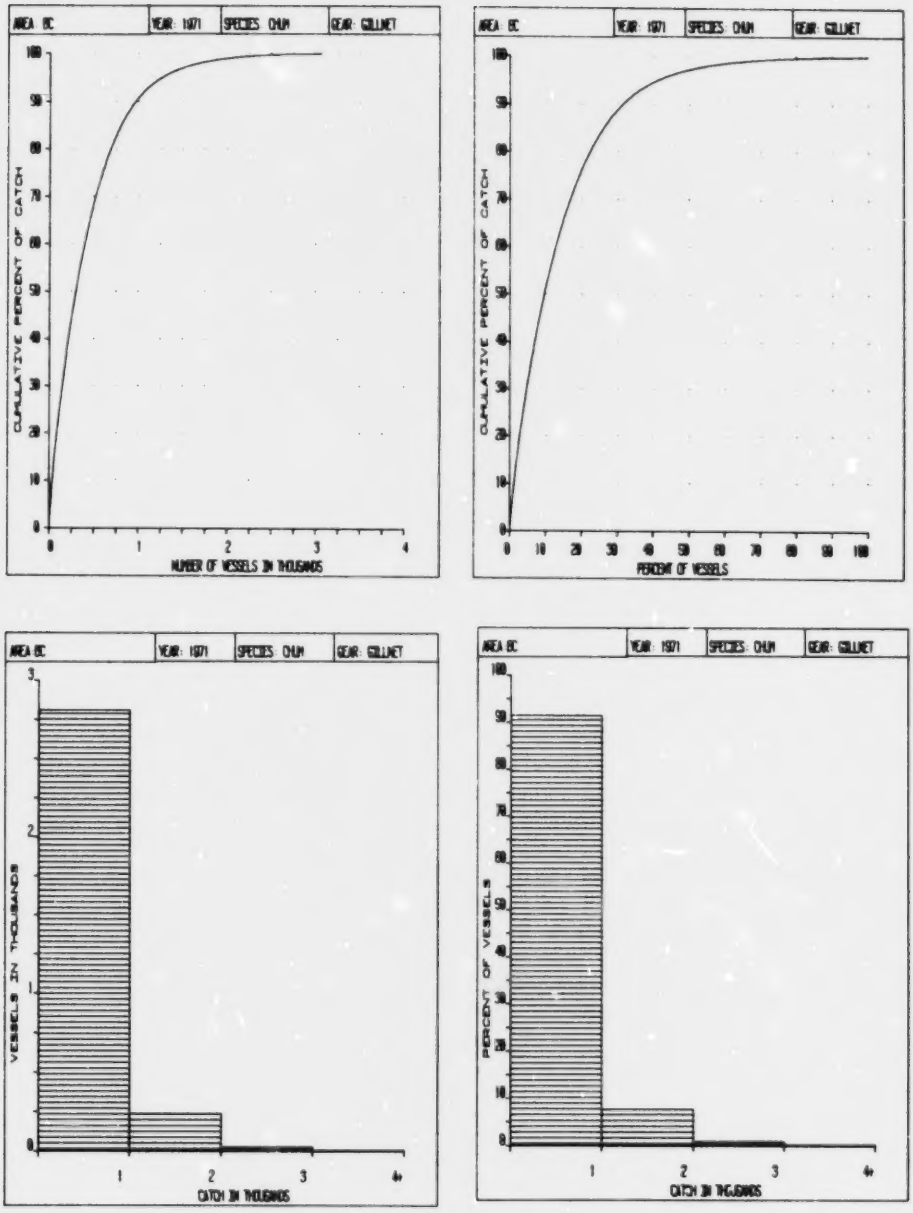

Fig. A5. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1971.

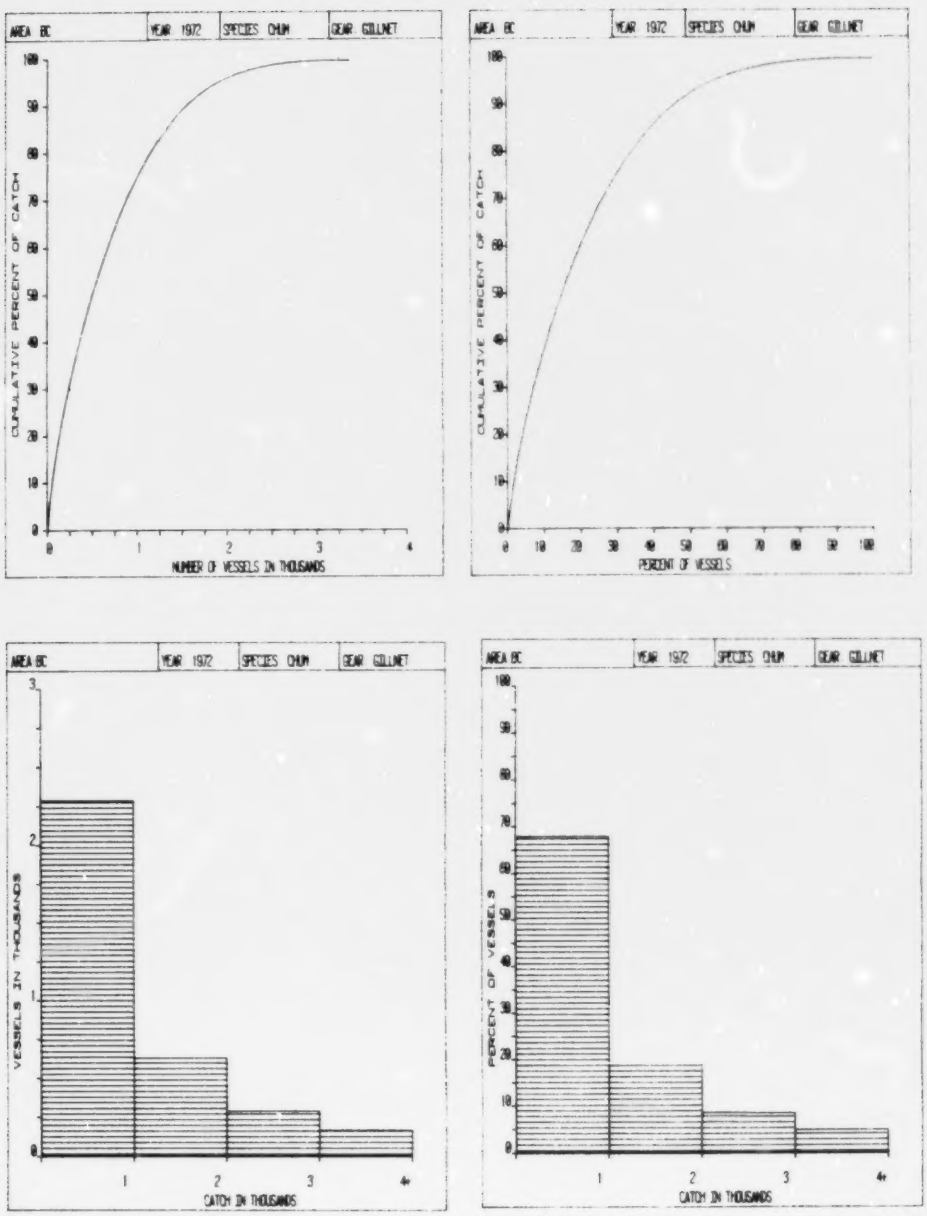

Fig. A6. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1972.

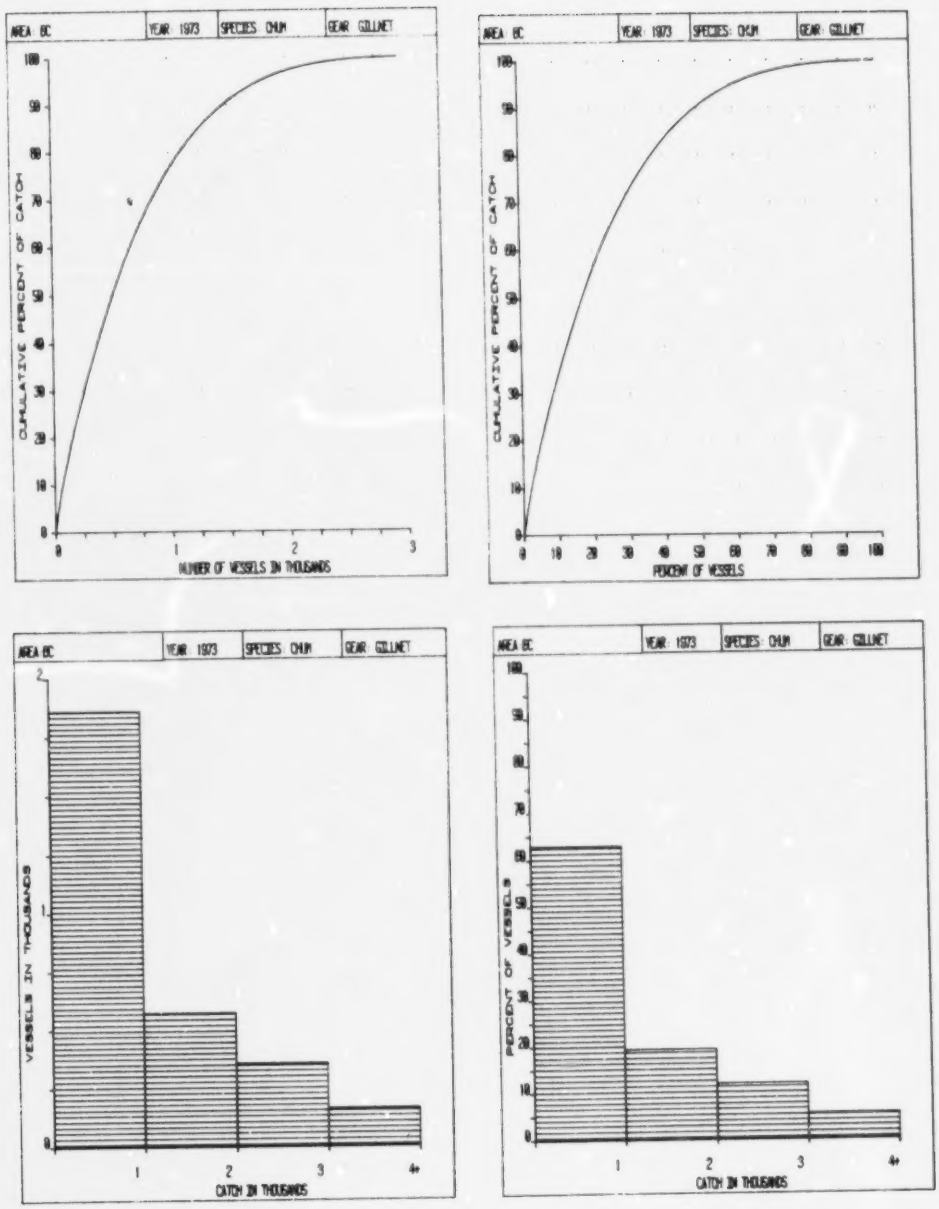

Fig. A7. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1973.

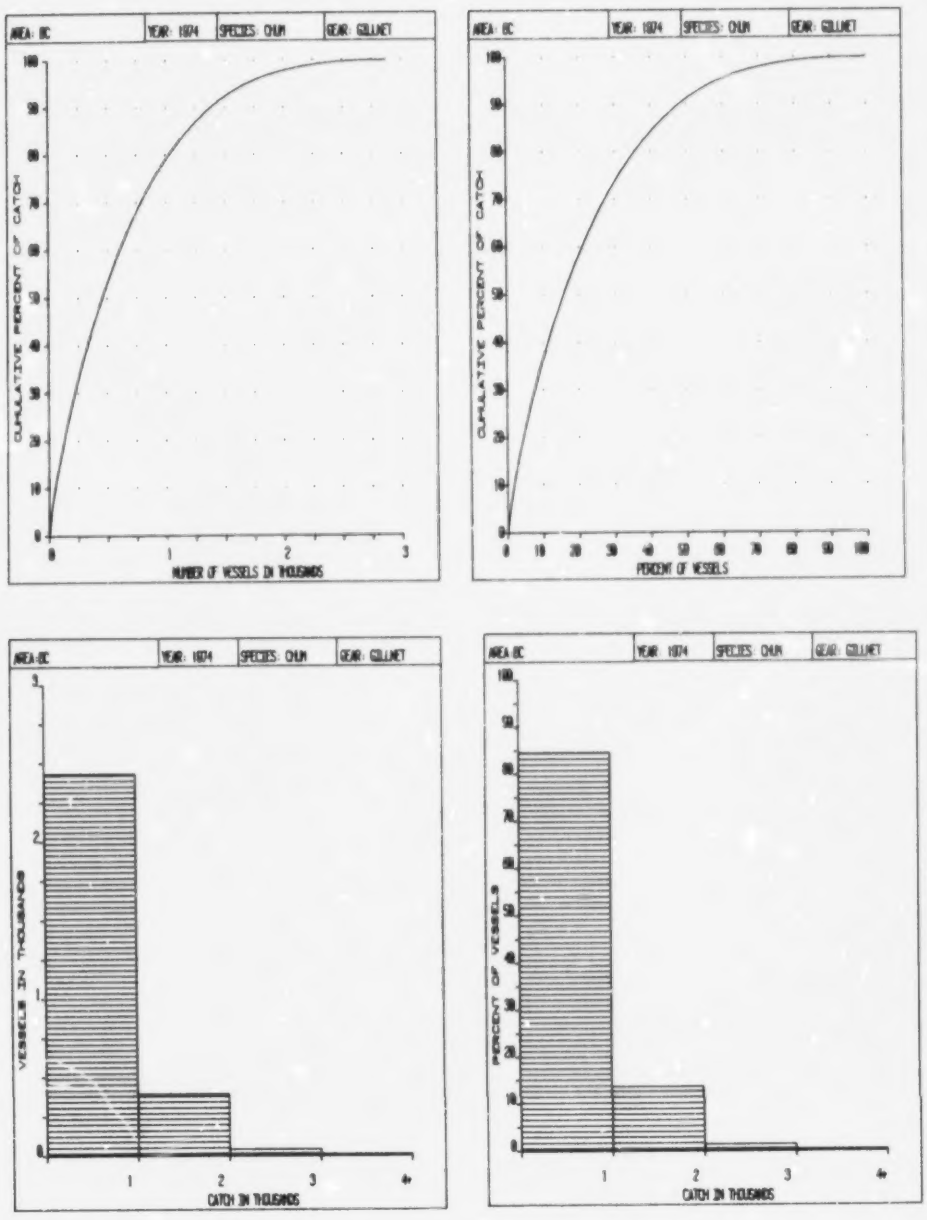

Fig. A8. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1974.

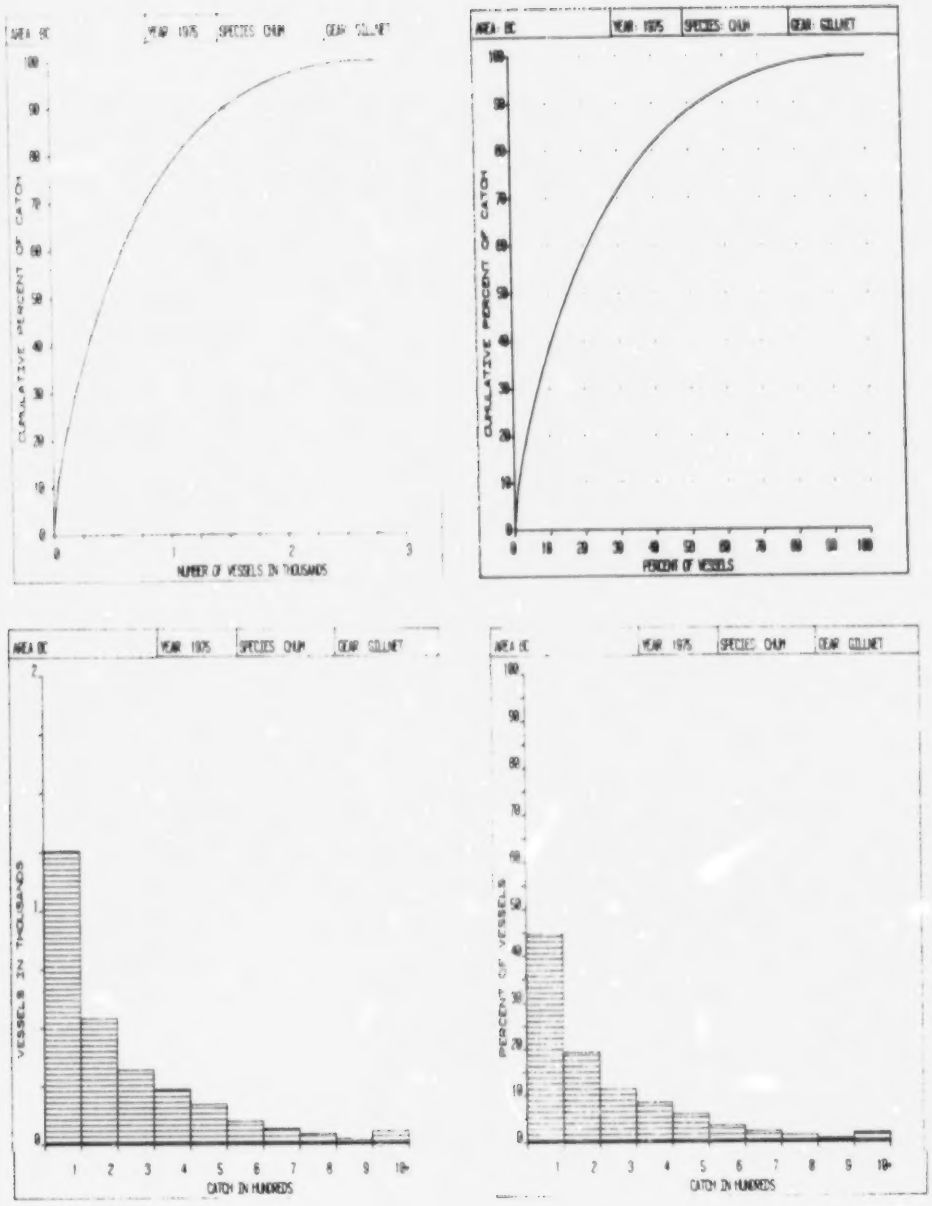

Fig. A9. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1975.

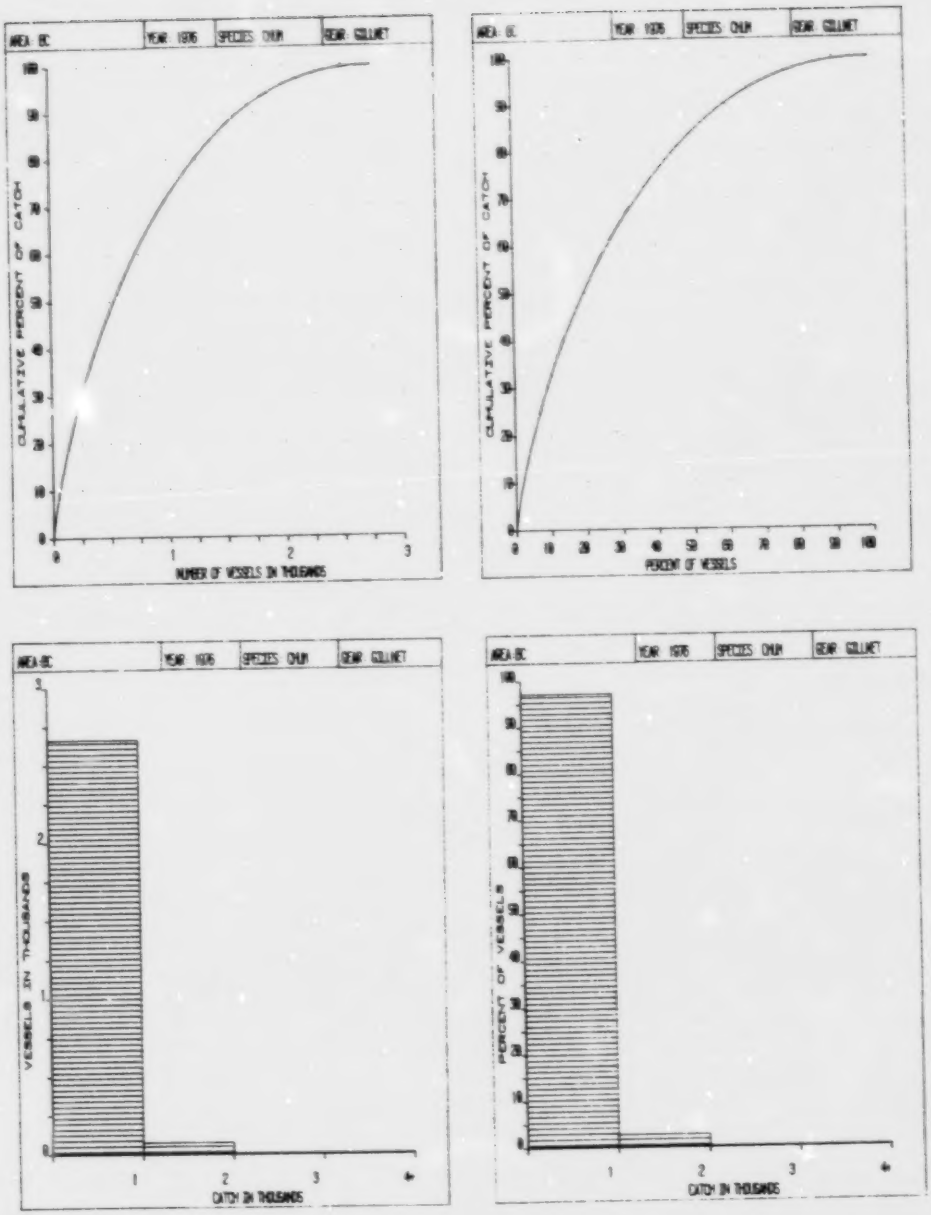

Fig. A10. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1976.

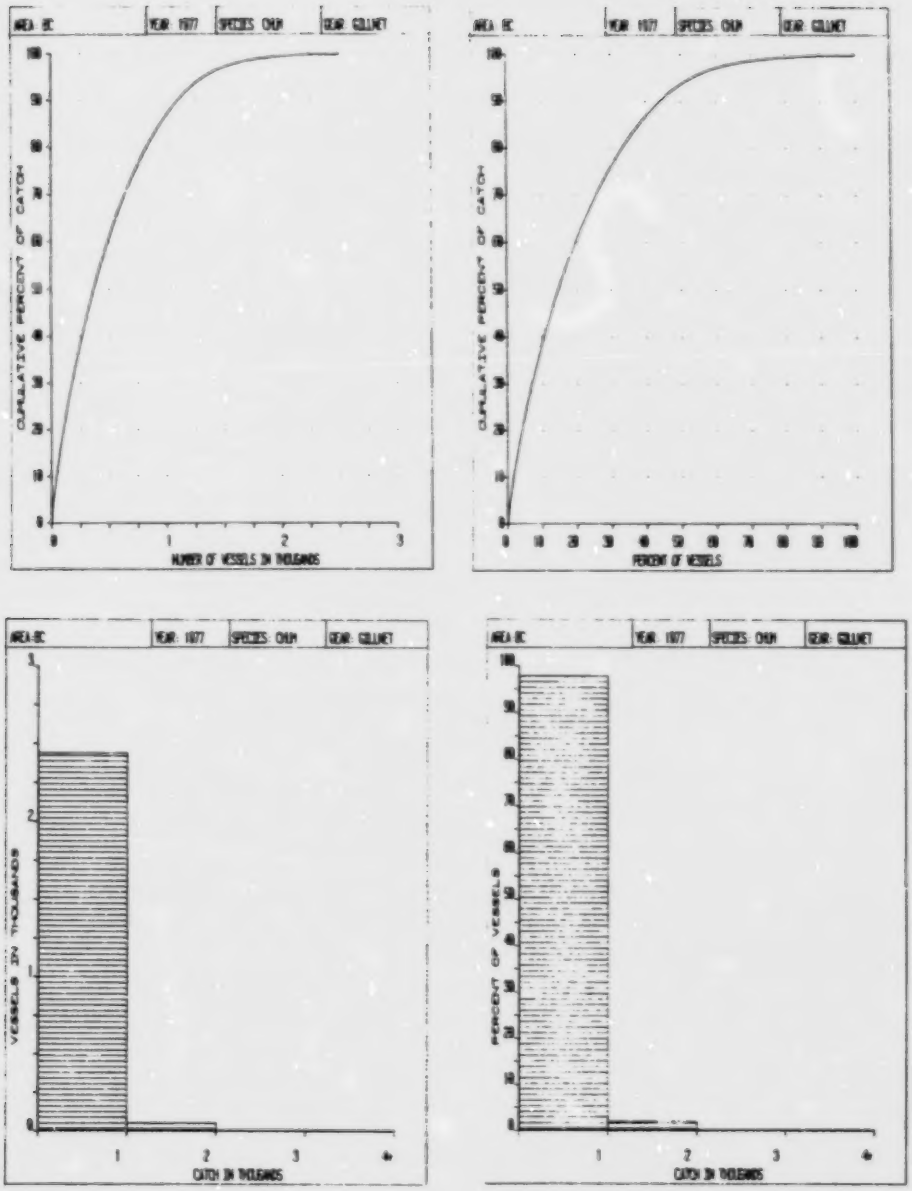

Fig. A11. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1977.

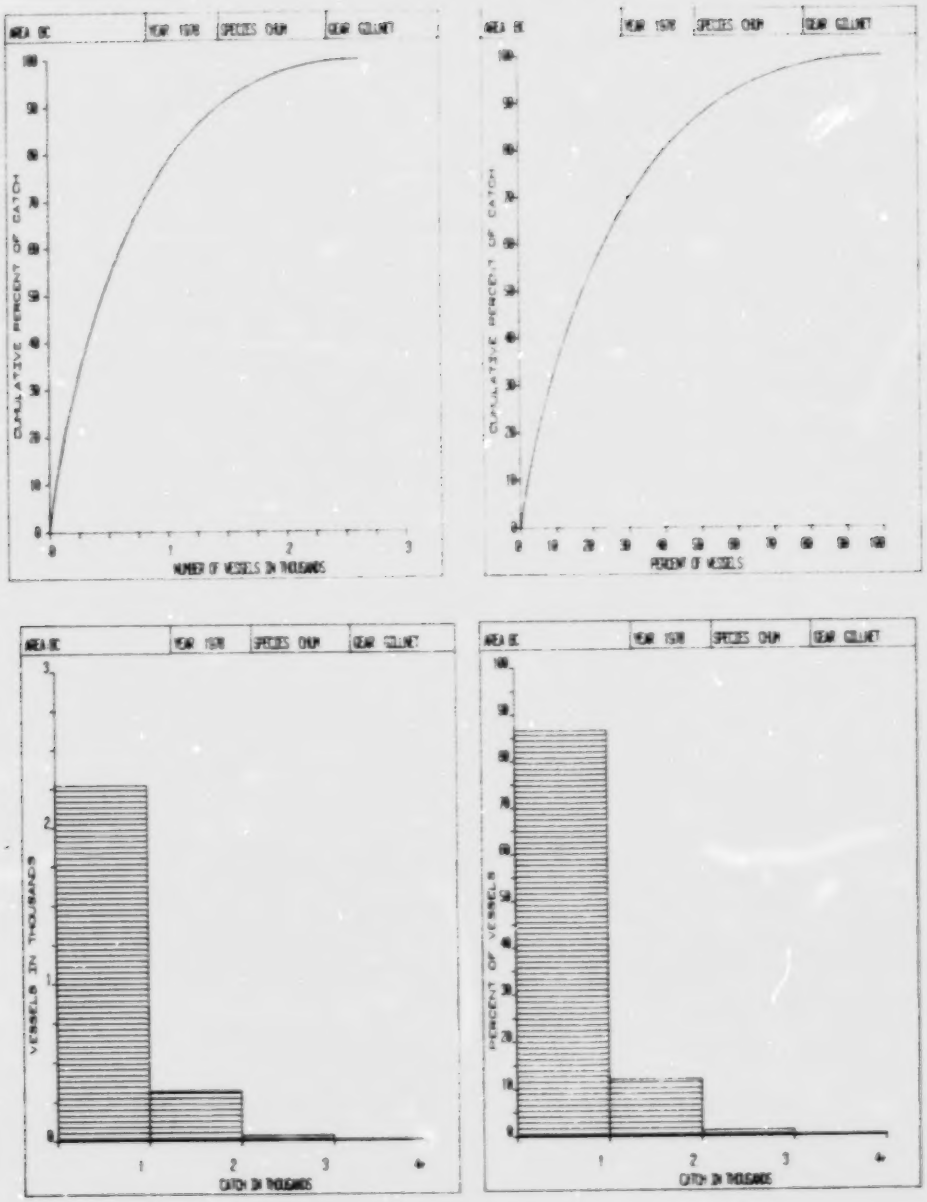

Fig. A12. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1978.

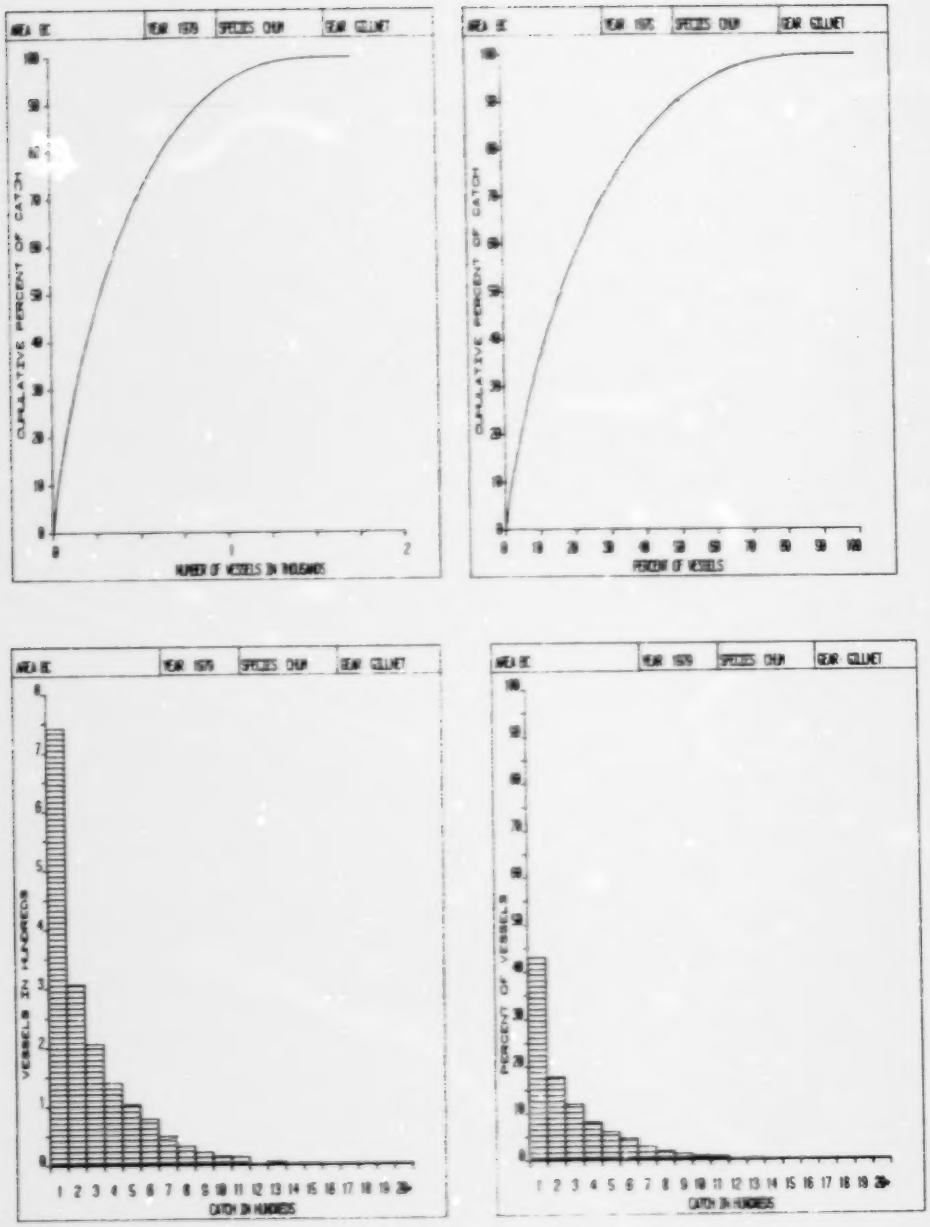

Fig. A13. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1979.

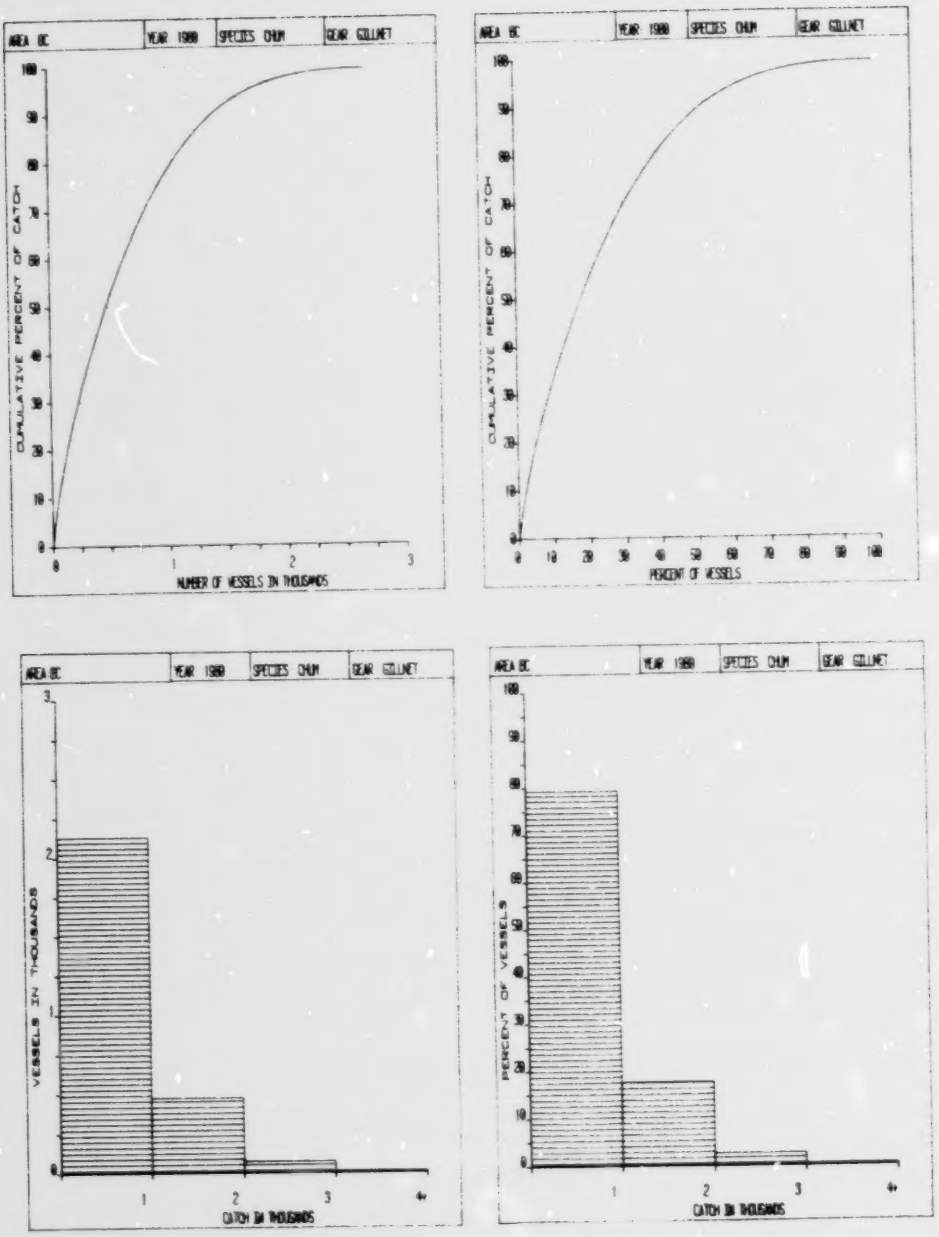

Fig. A14. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and articipated in the fishery, 1980.

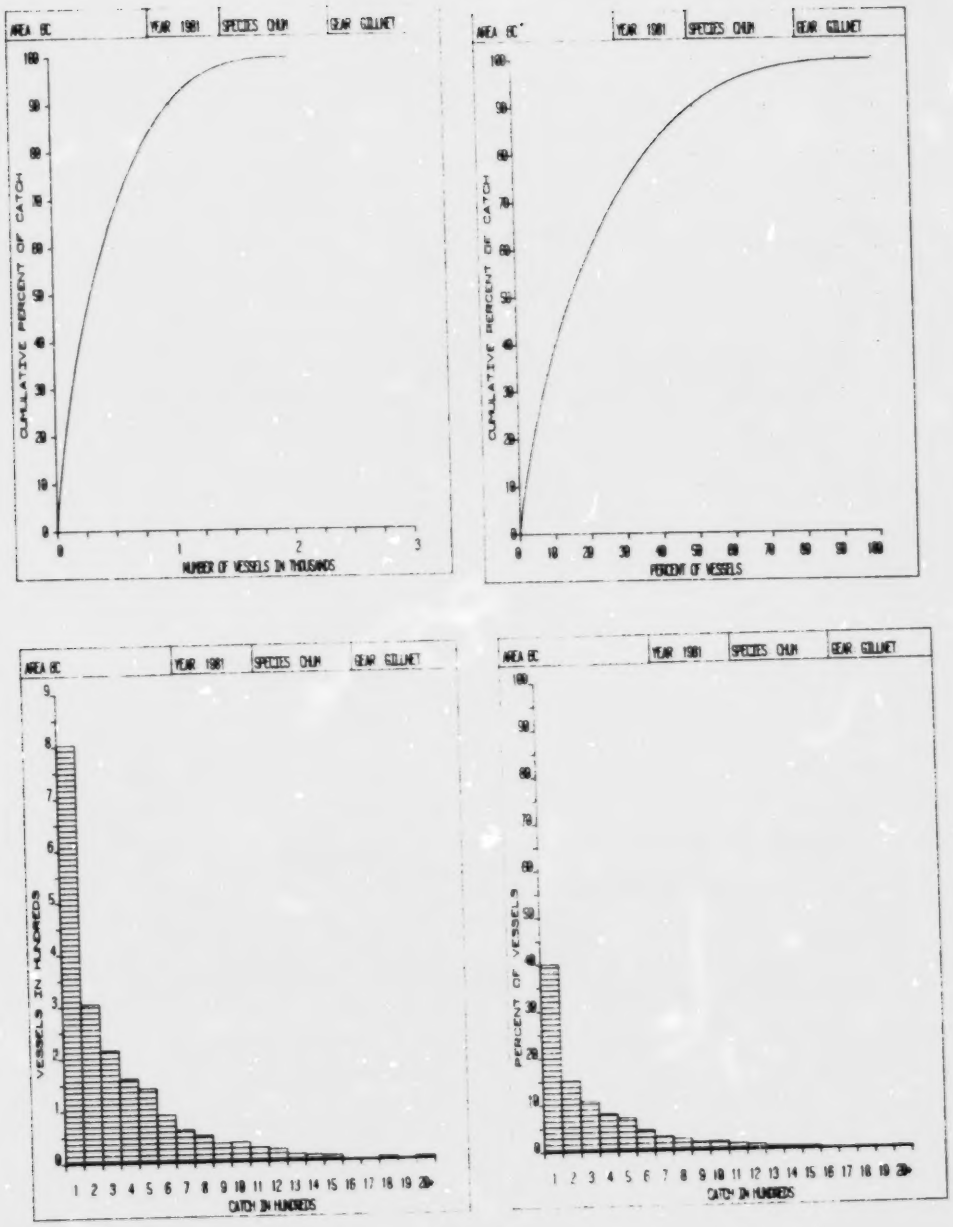

Fig. A15. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1981.

APPENDIX B

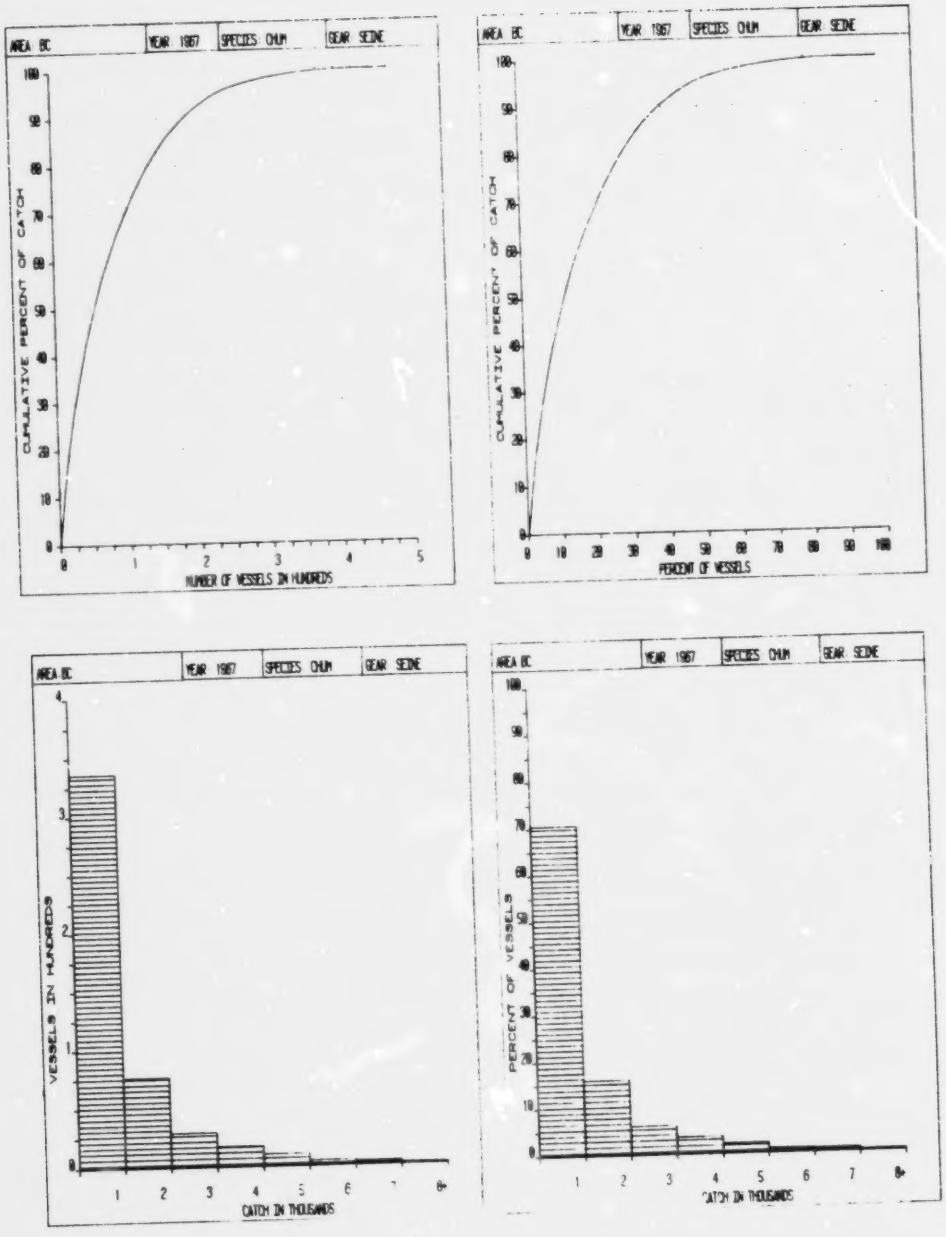

Fig. B1. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1967.

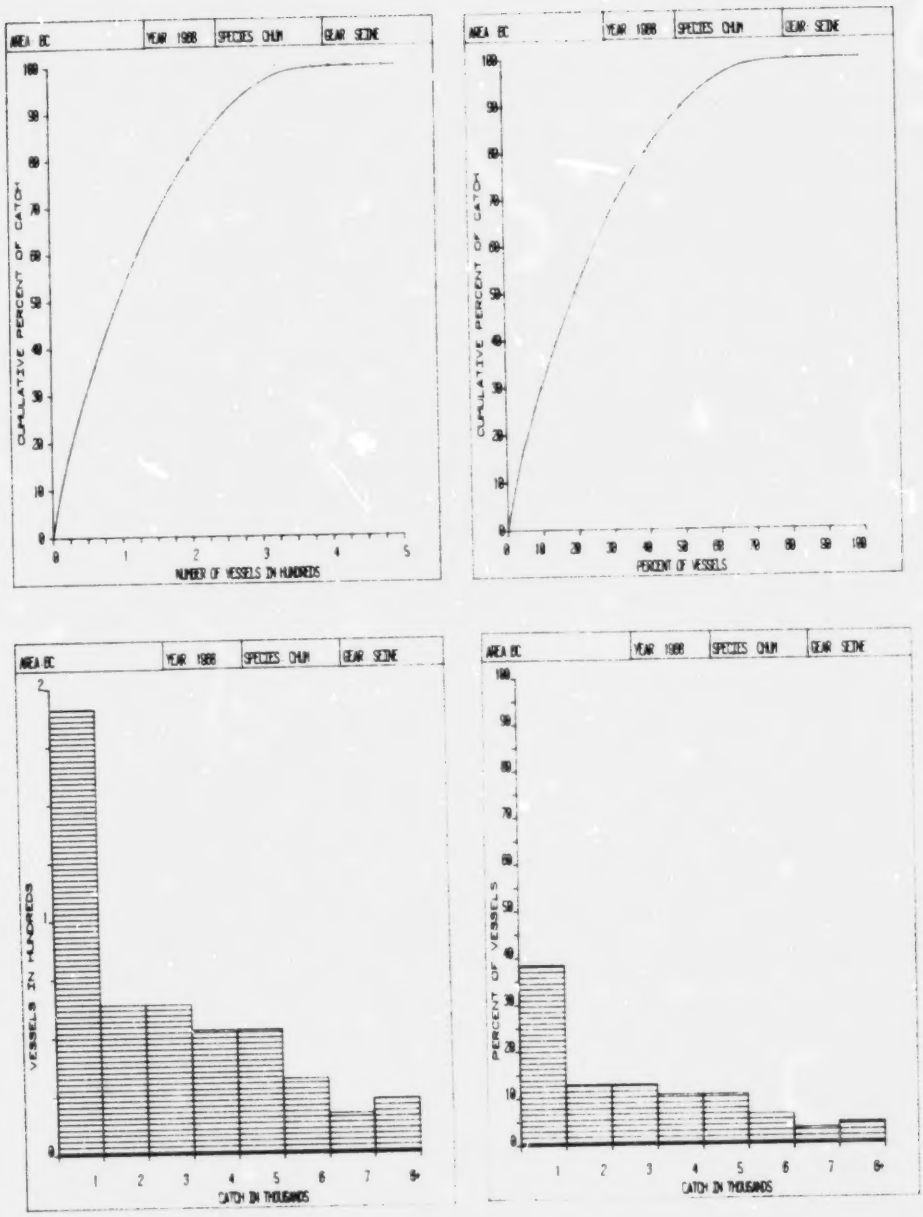

Fig. B2. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1968.

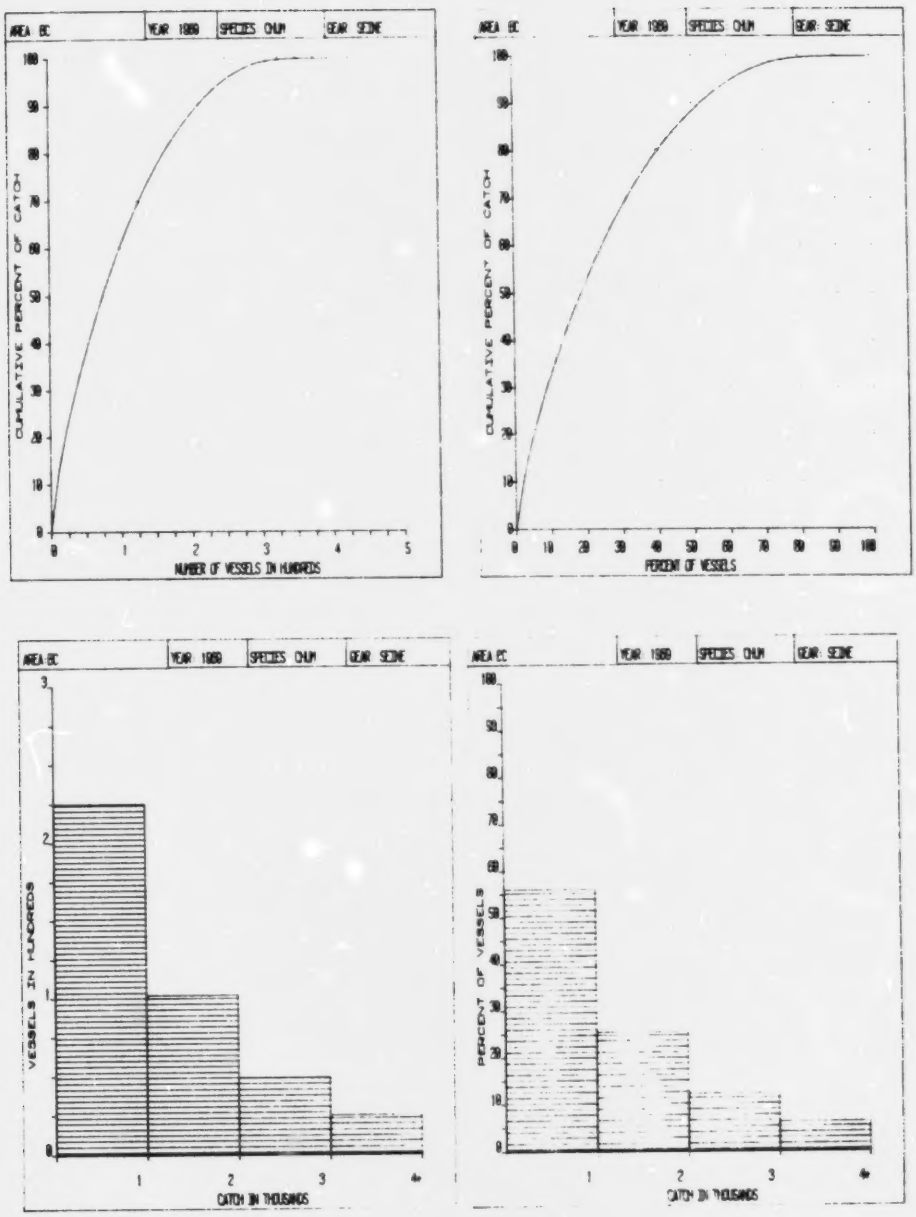

Fig. B3. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1969.

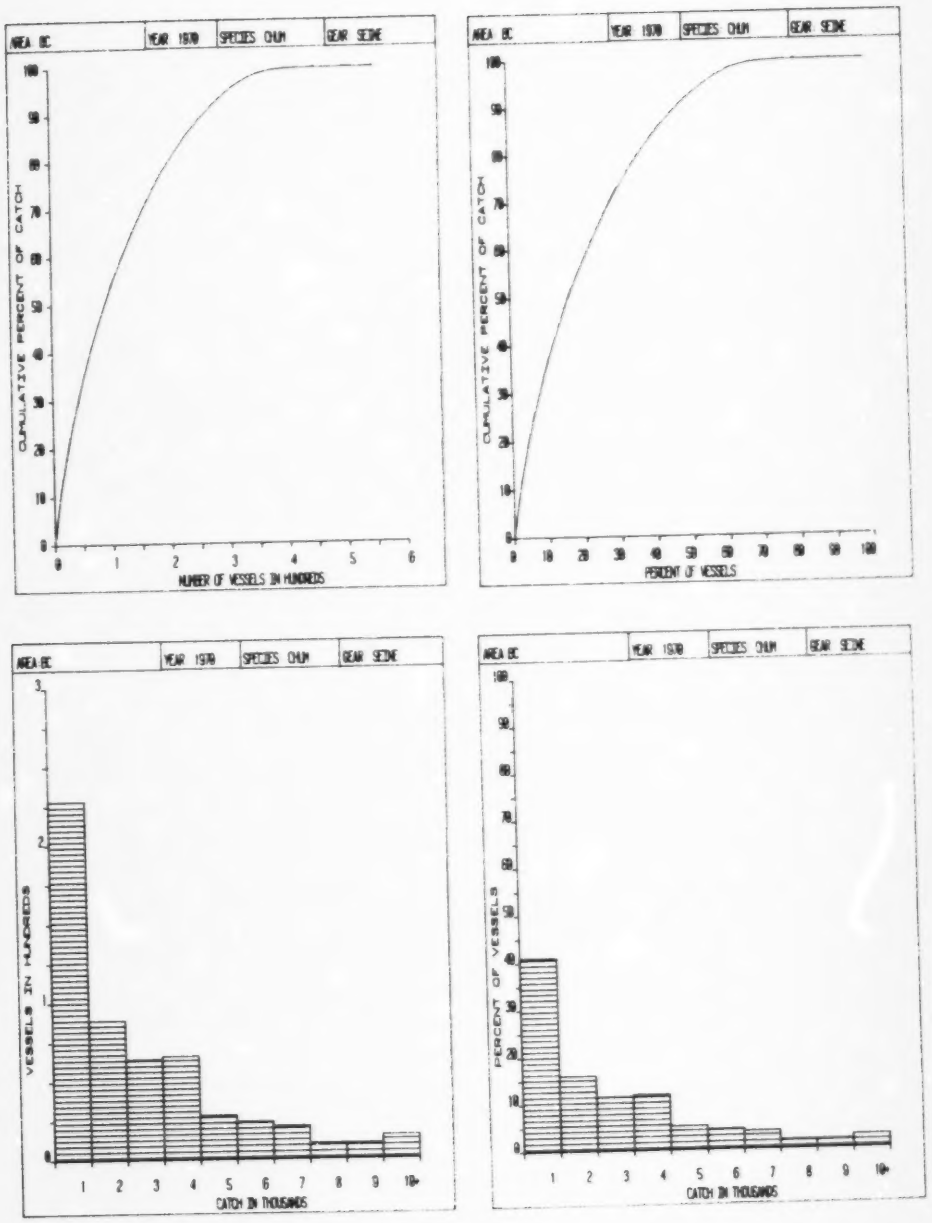

Fig. B4. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1970.

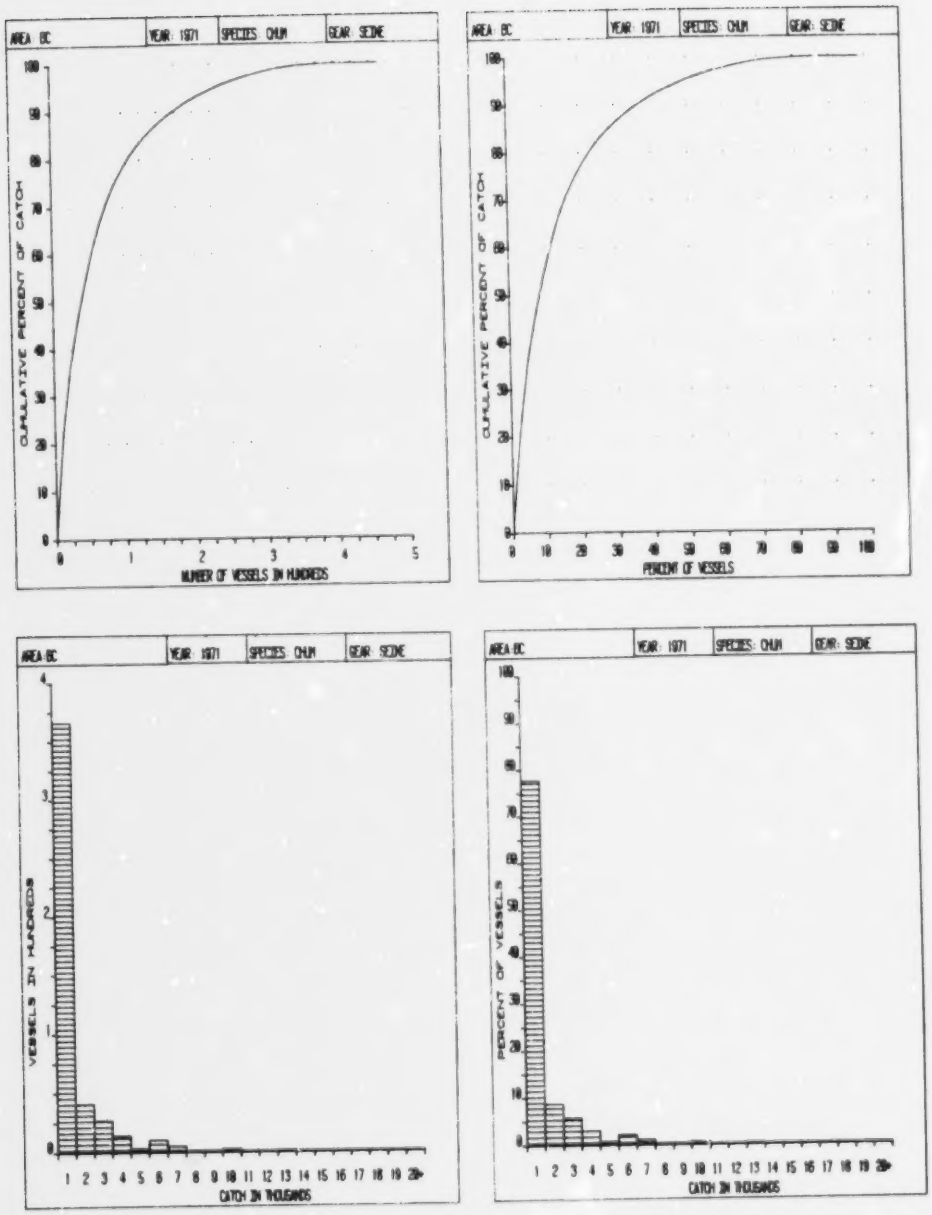

Fig. B5. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1971.

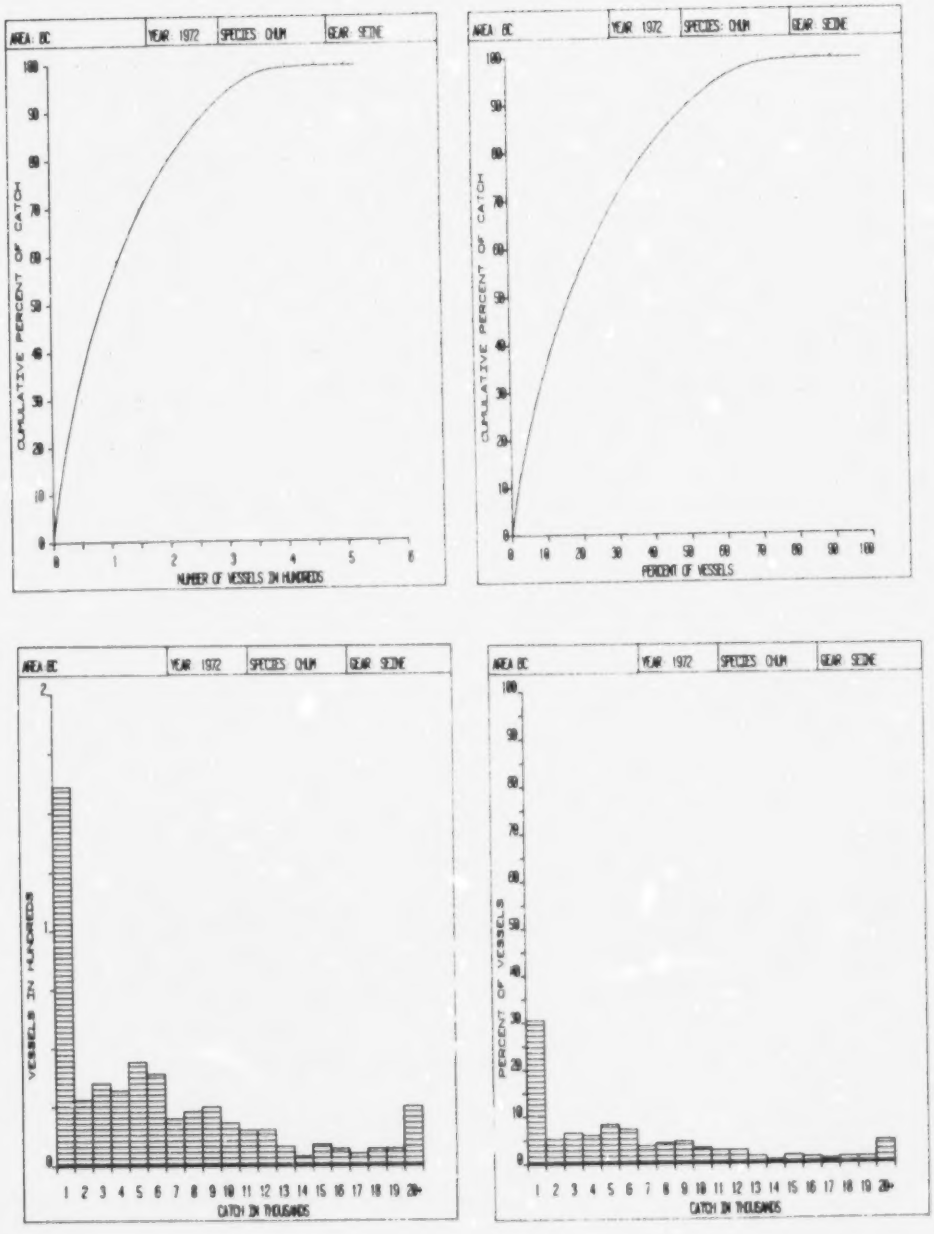

Fig. B6. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1972.

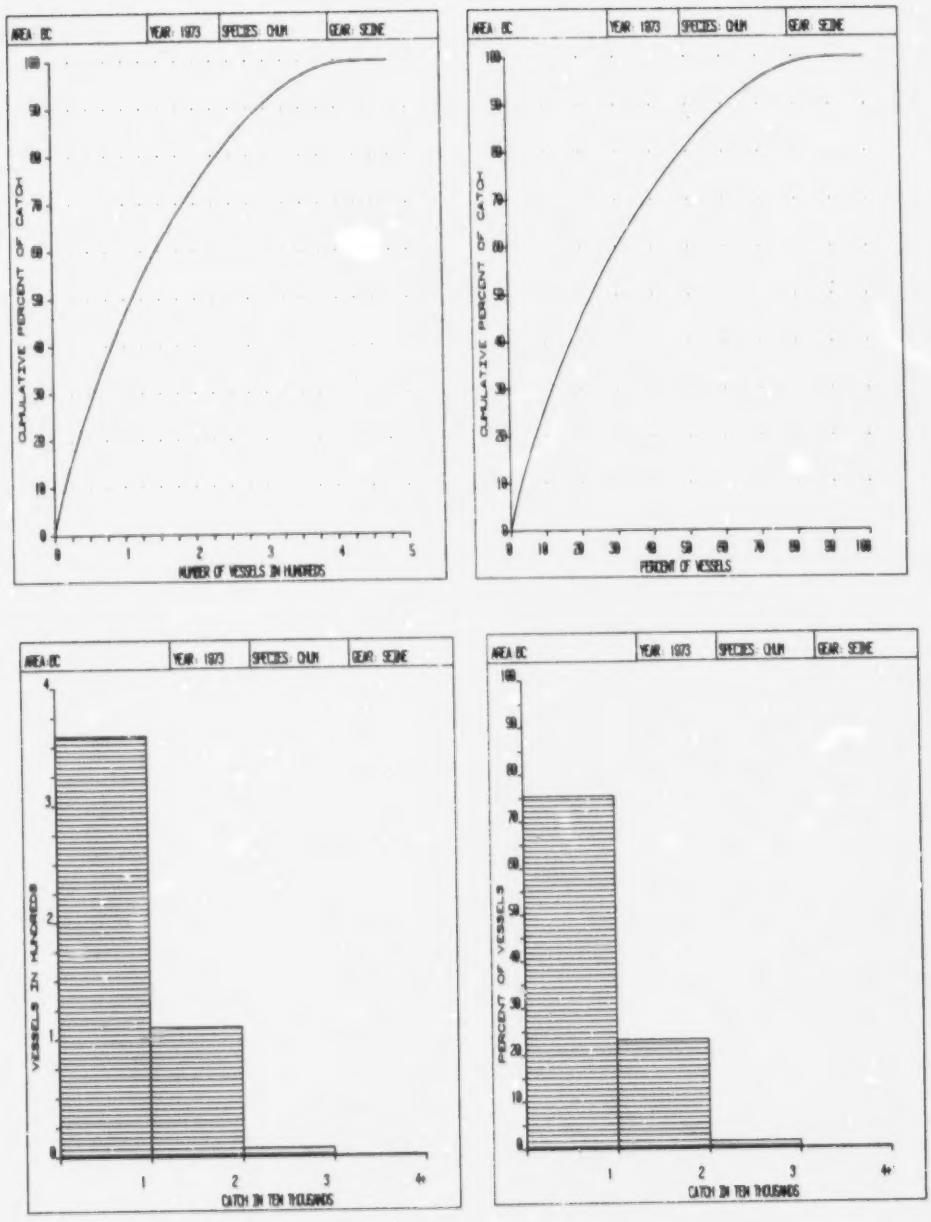

Fig. B7. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1973.

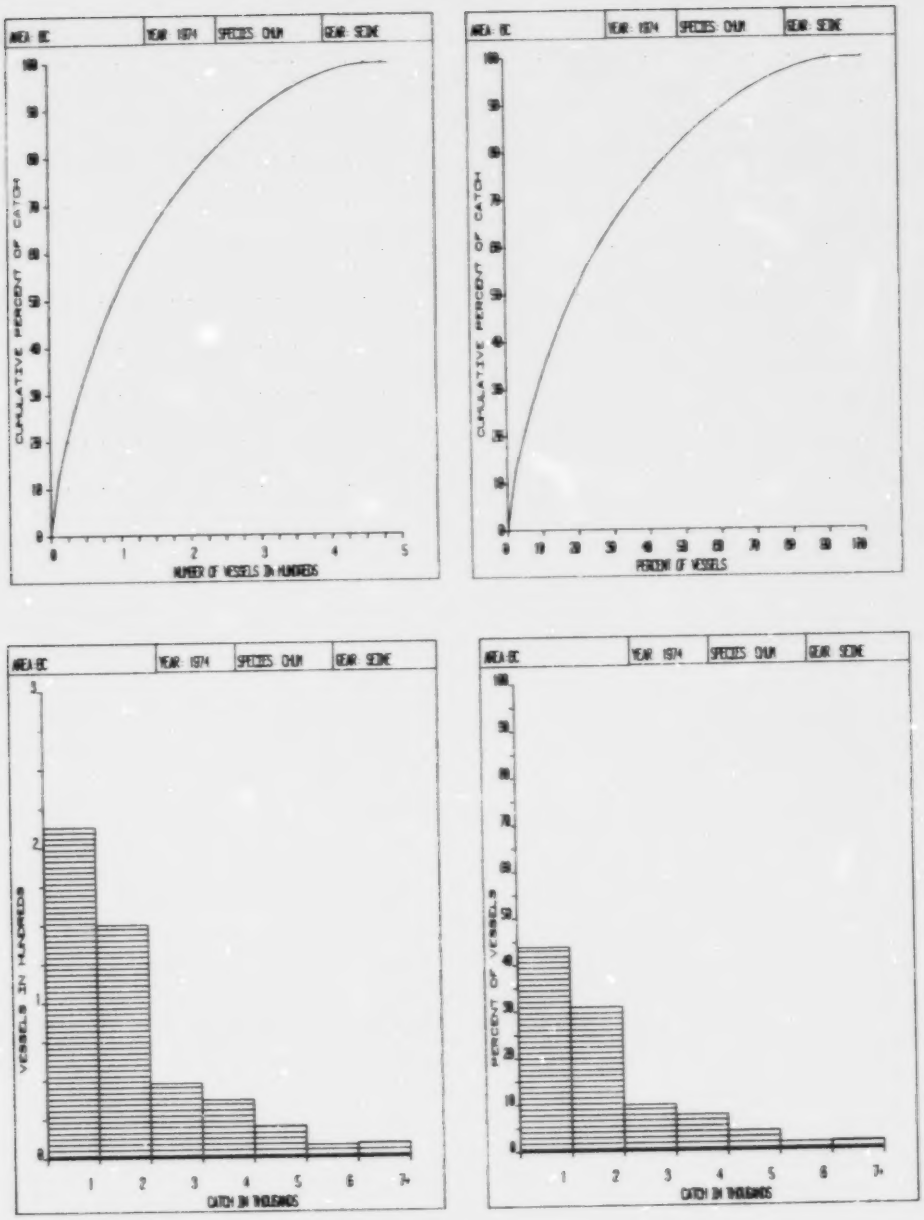

Fig. B8. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1974.

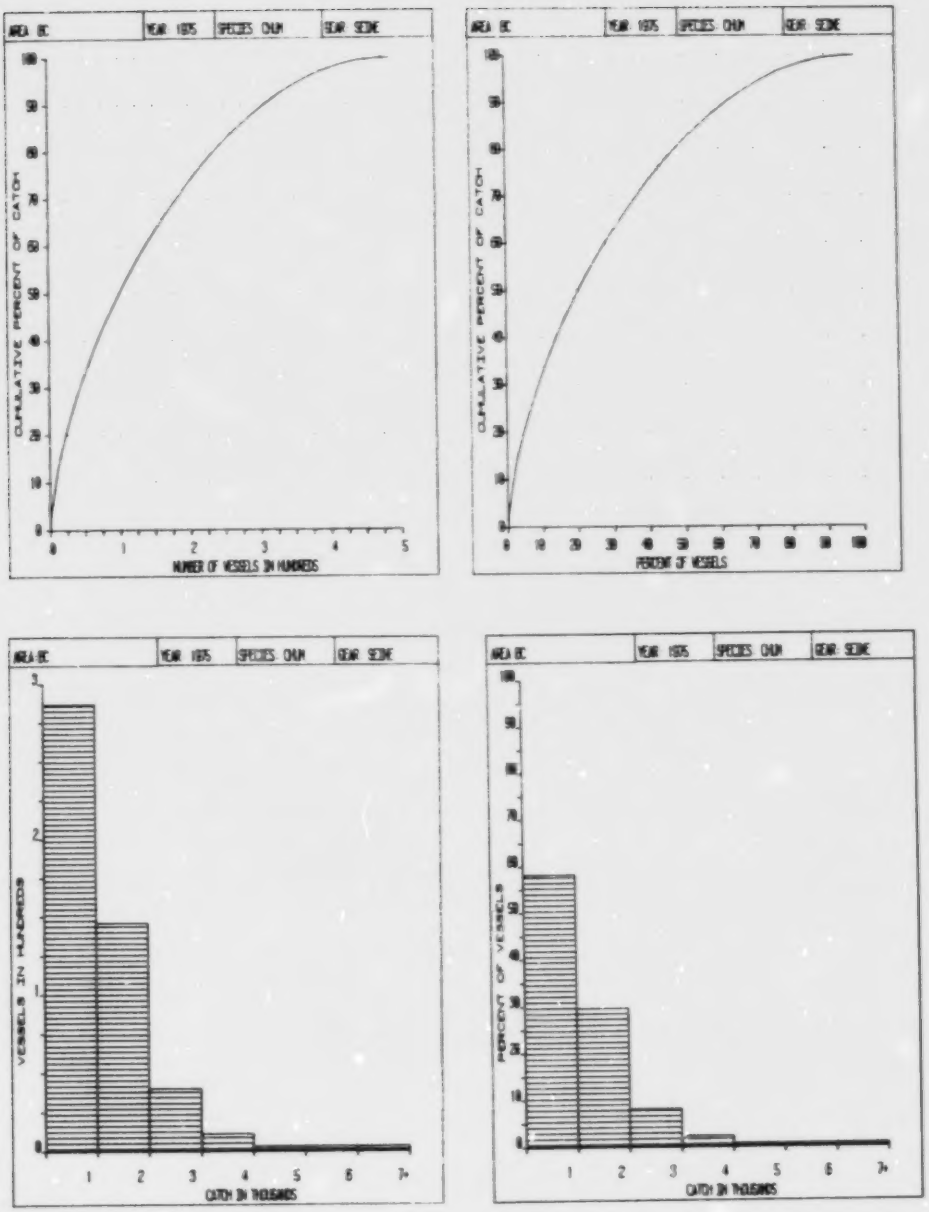

Fig. 69. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1975.

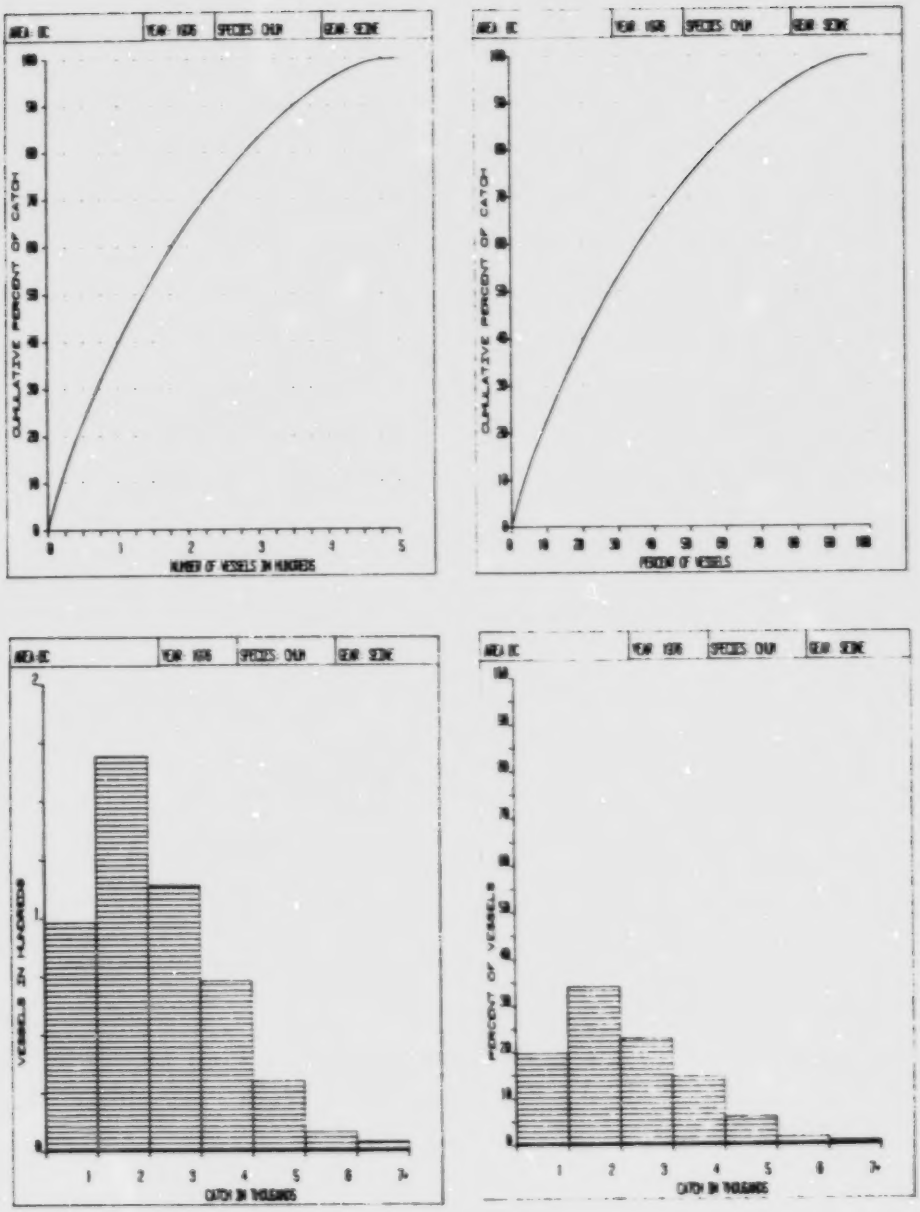

Fig. B10. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1976.

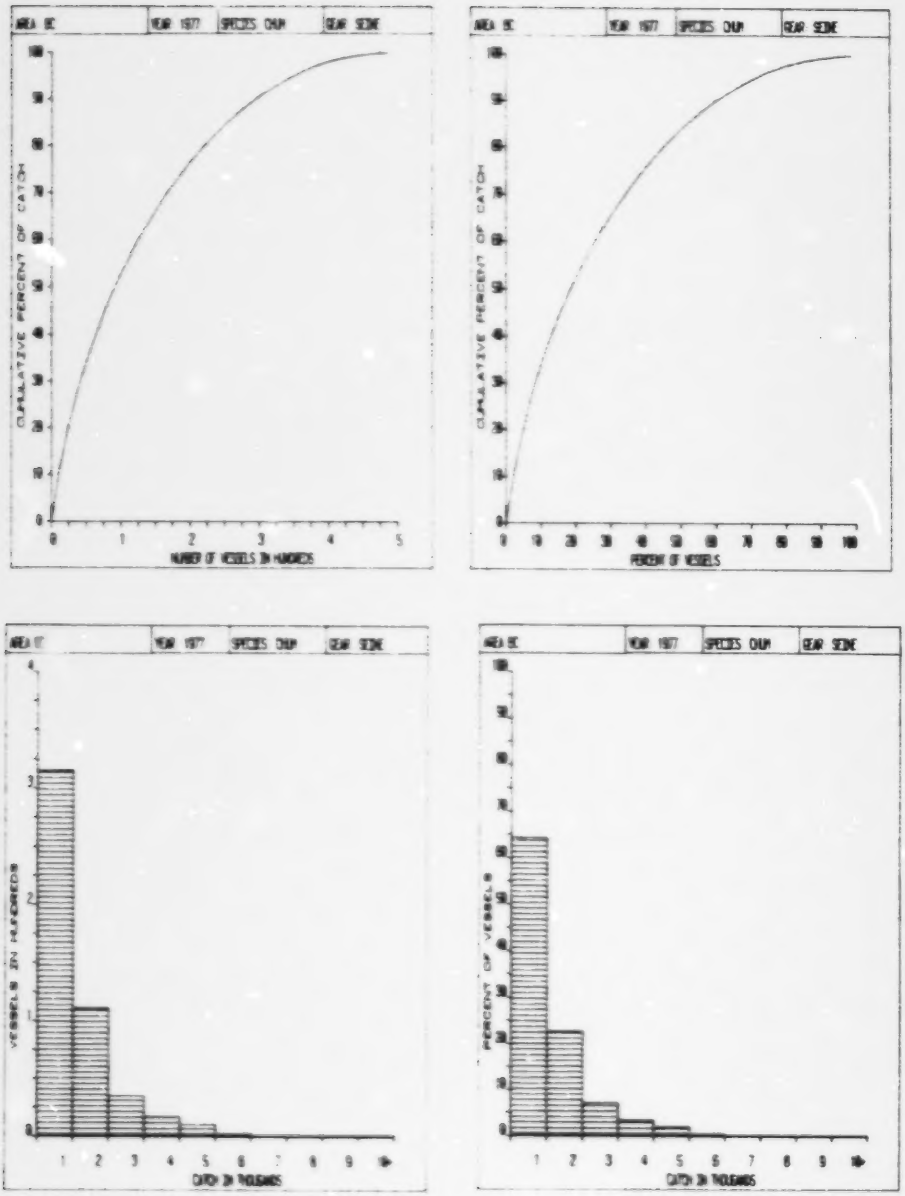

Fig. B11. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1977.

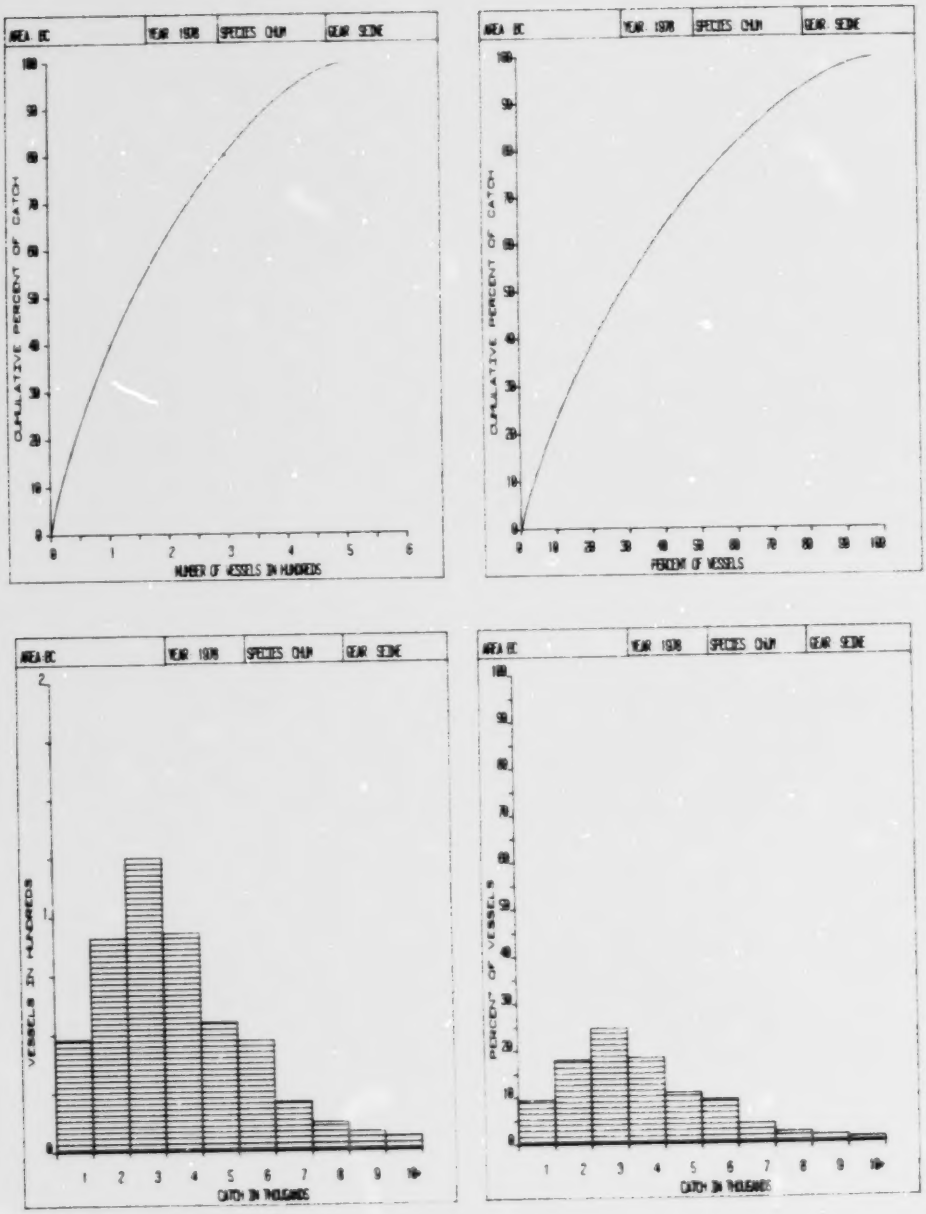

Fig. B12. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1978.

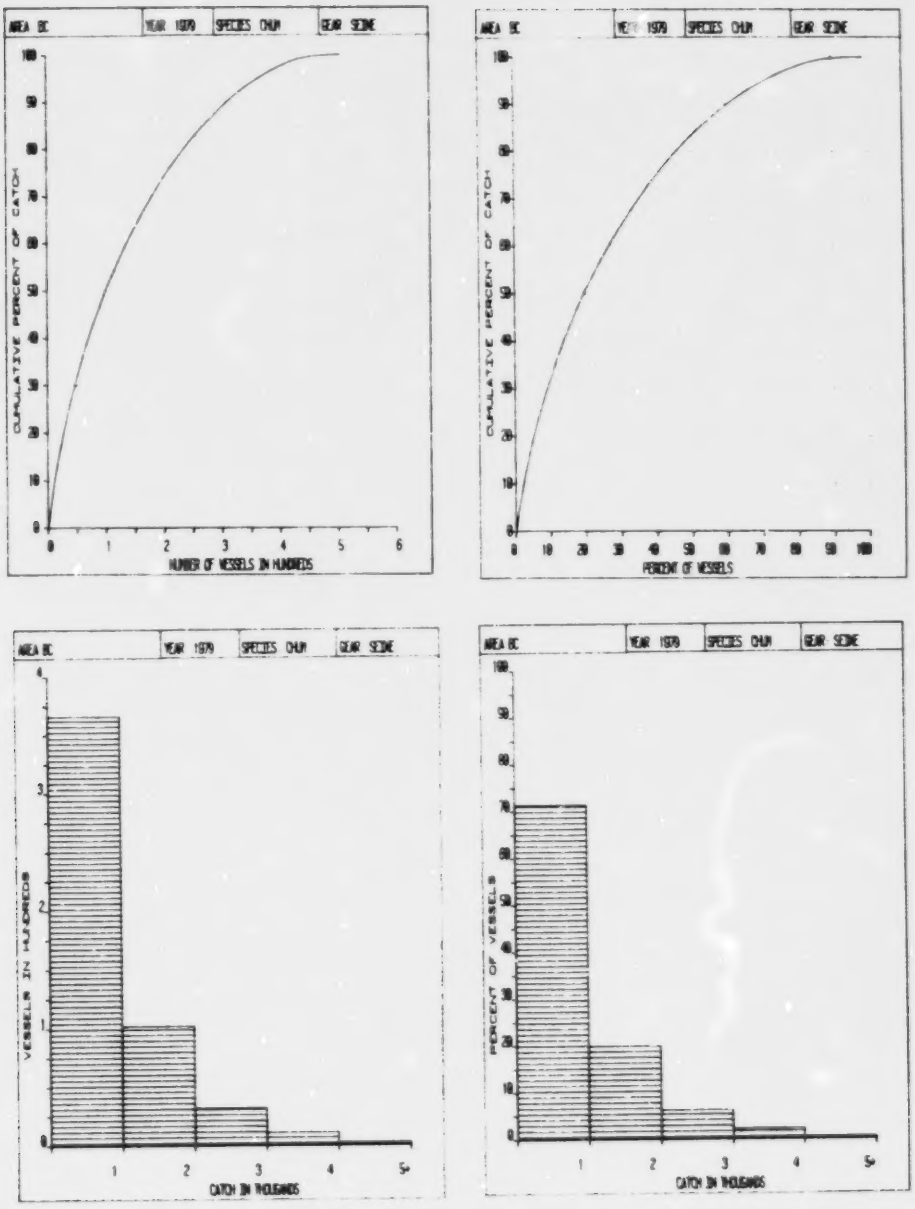

Fig. B13. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1979.

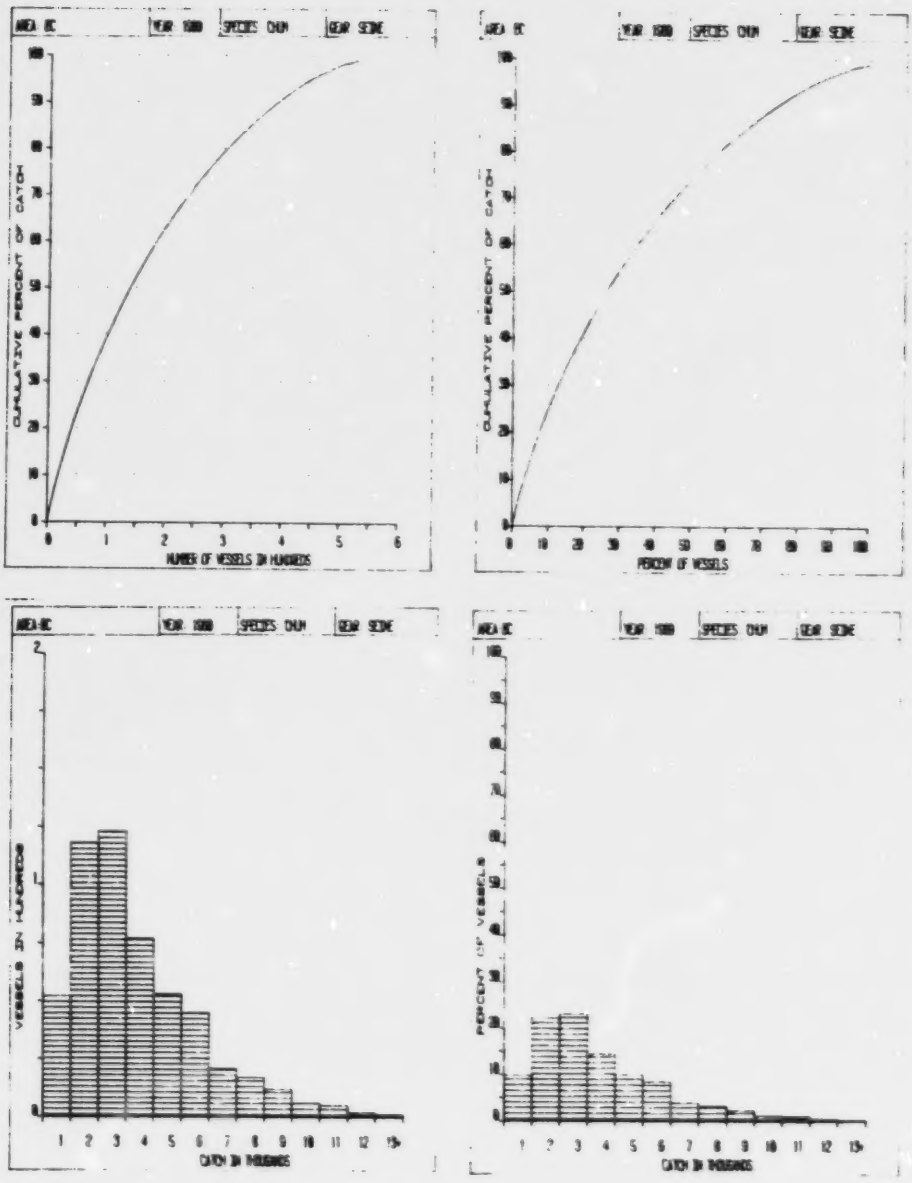

Fig. B14. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1980.

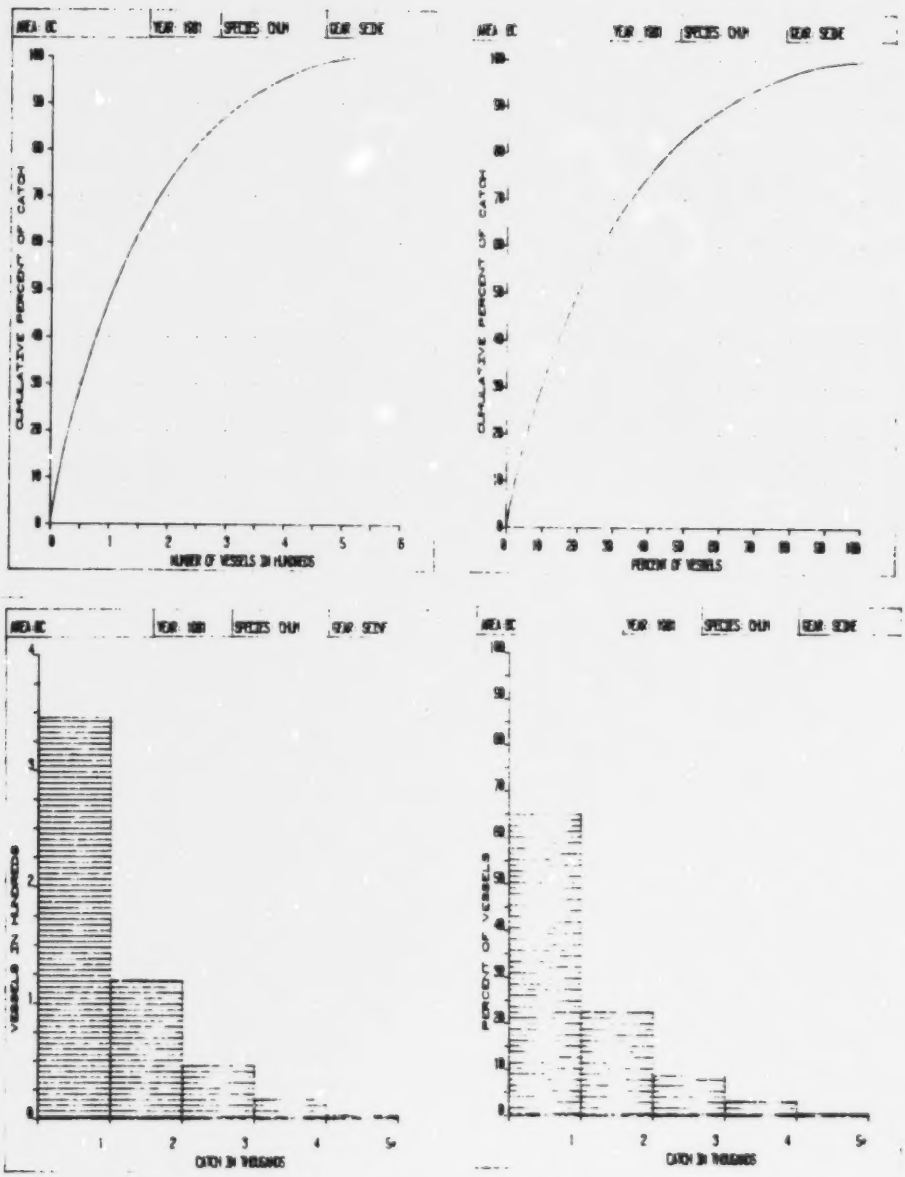

Fig. B15. Cumulative percent and frequency of catch of chum salmon versus number and percent of purse seiners that participated in the fishery, 1981.

APPENDIX C

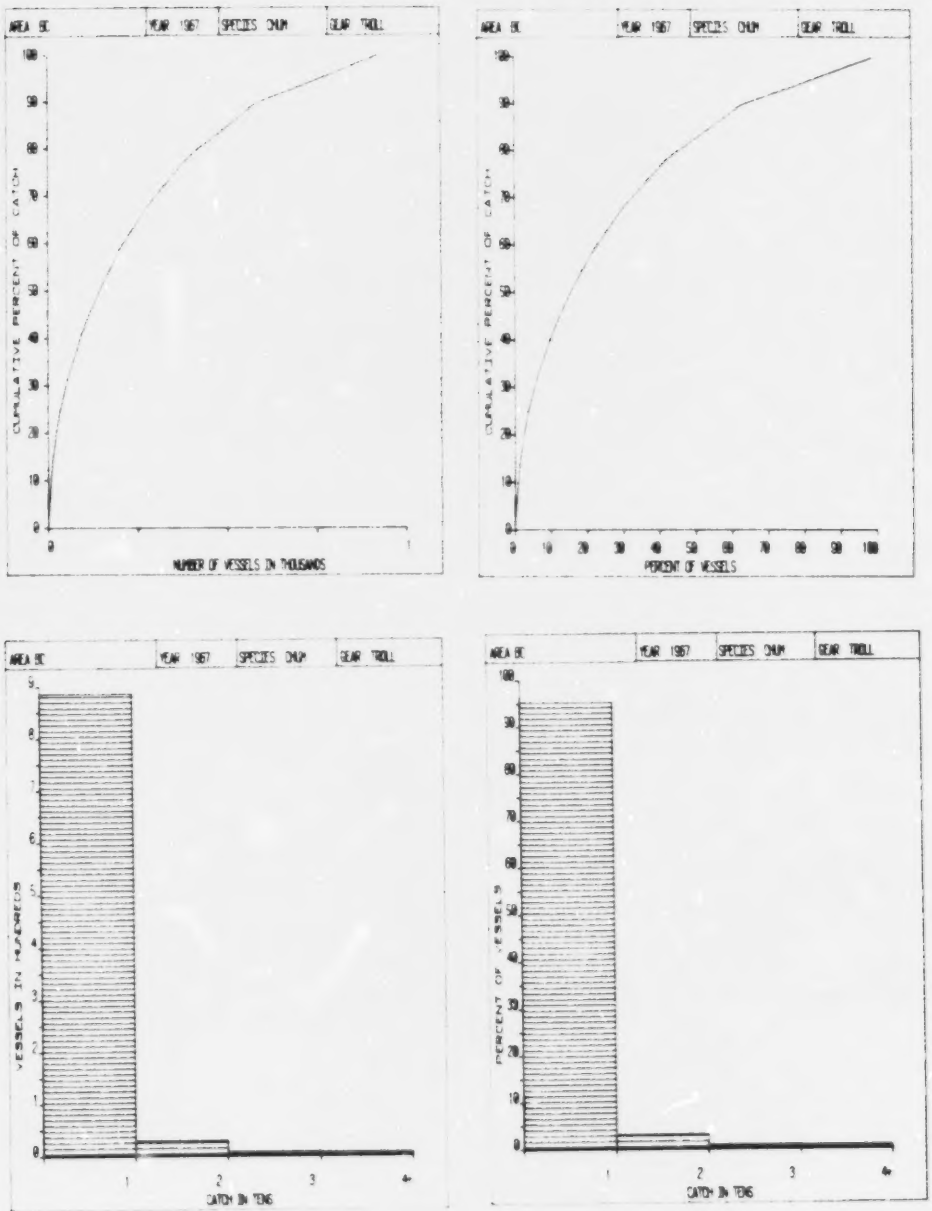

Fig. C1. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1967.

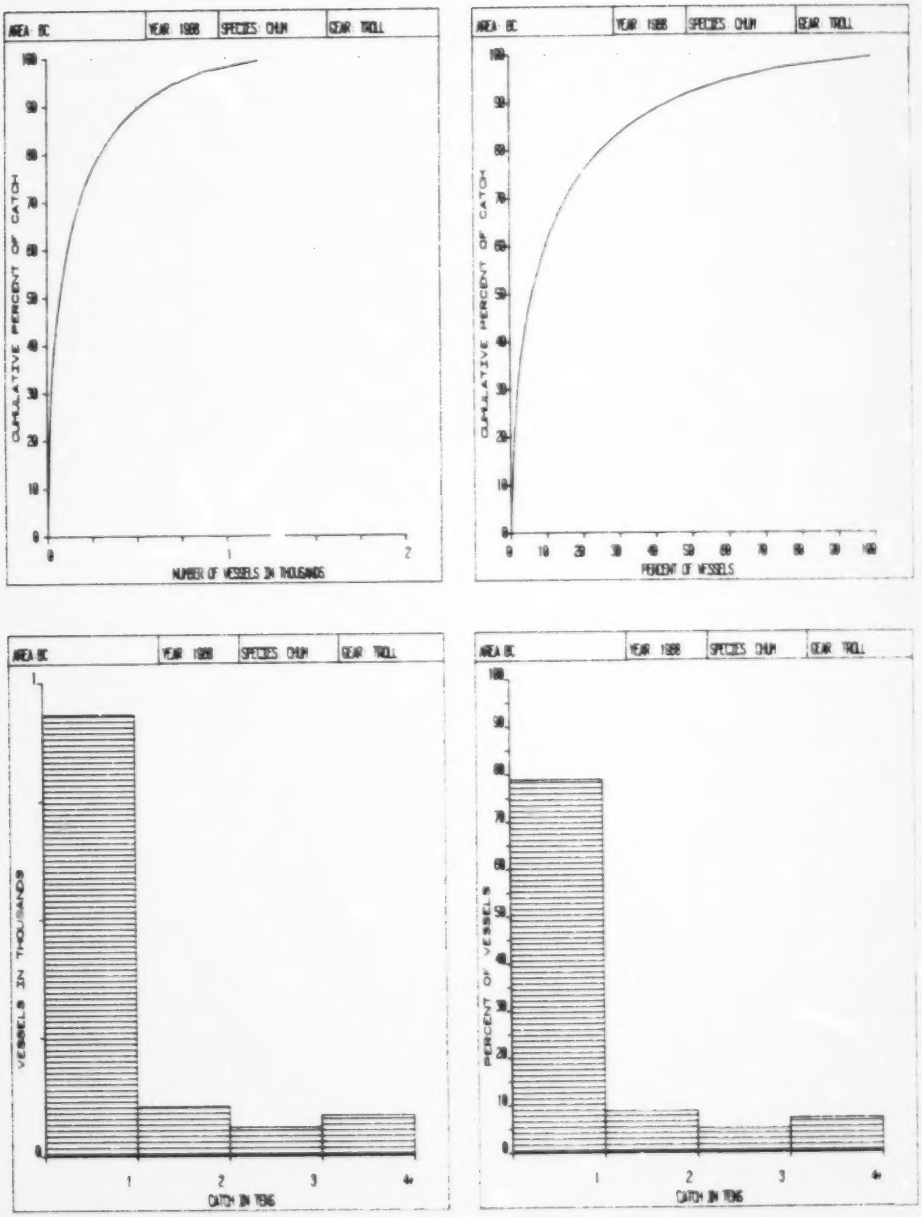

Fig. C2. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1968.

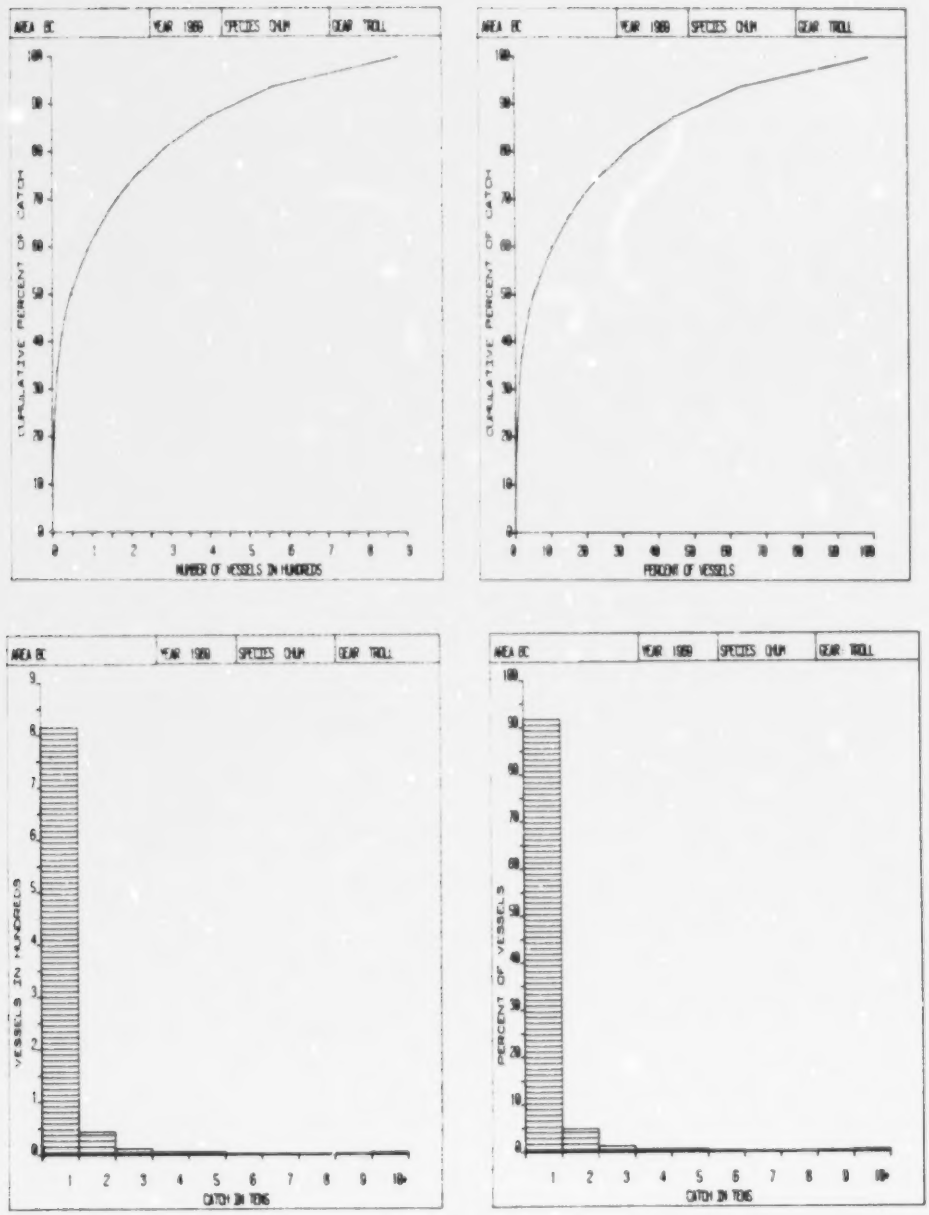

Fig. C3. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1969.

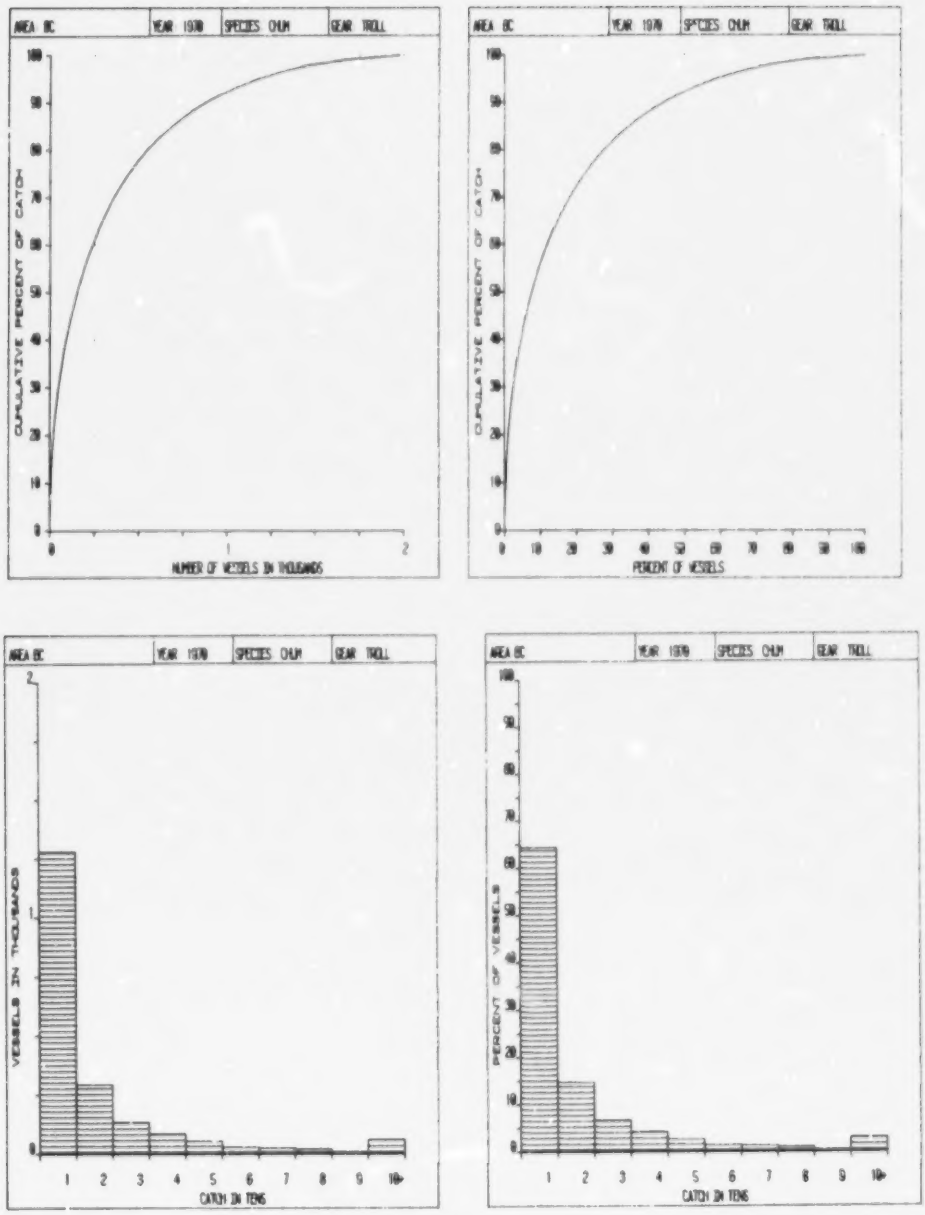

Fig. C4. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1970.

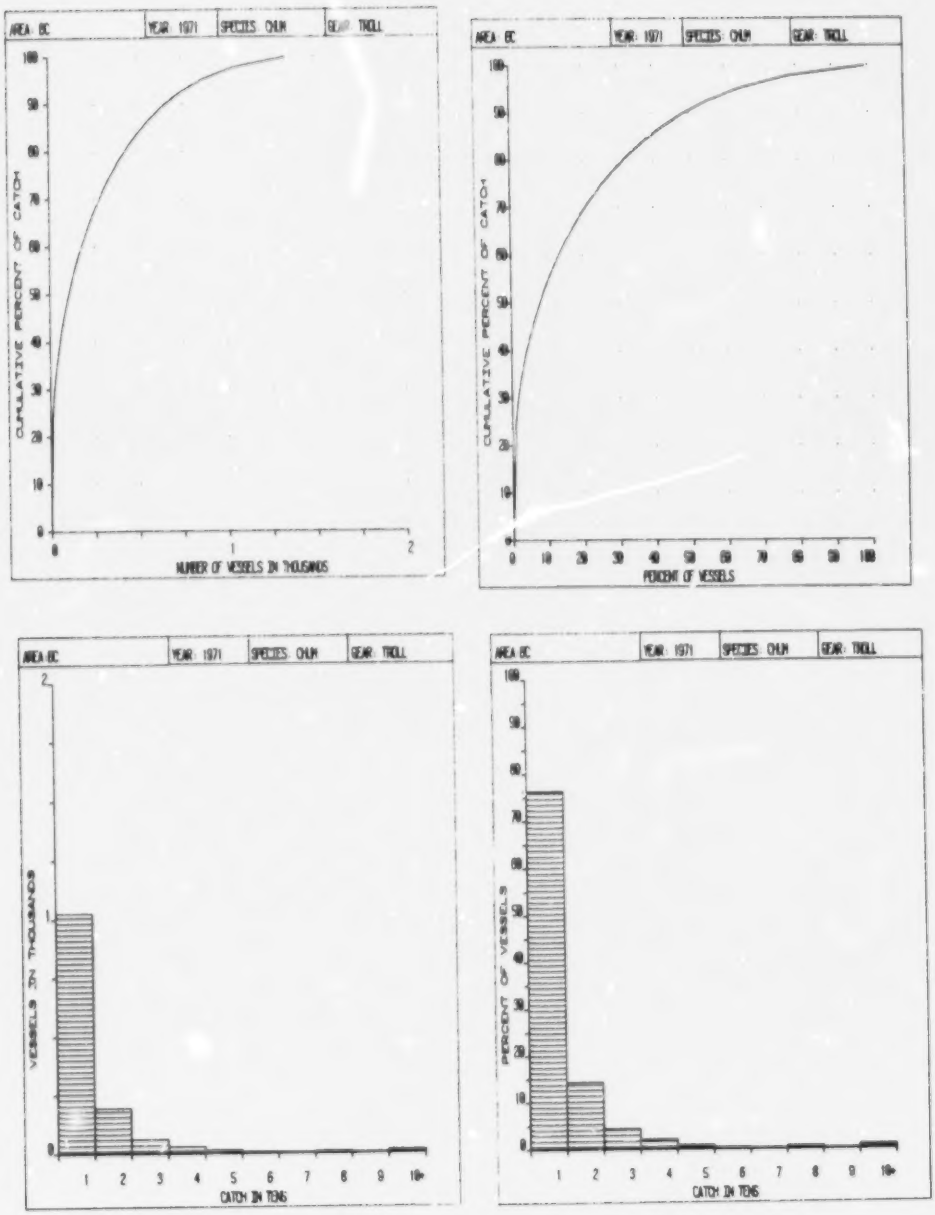

Fig. C5. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1971.

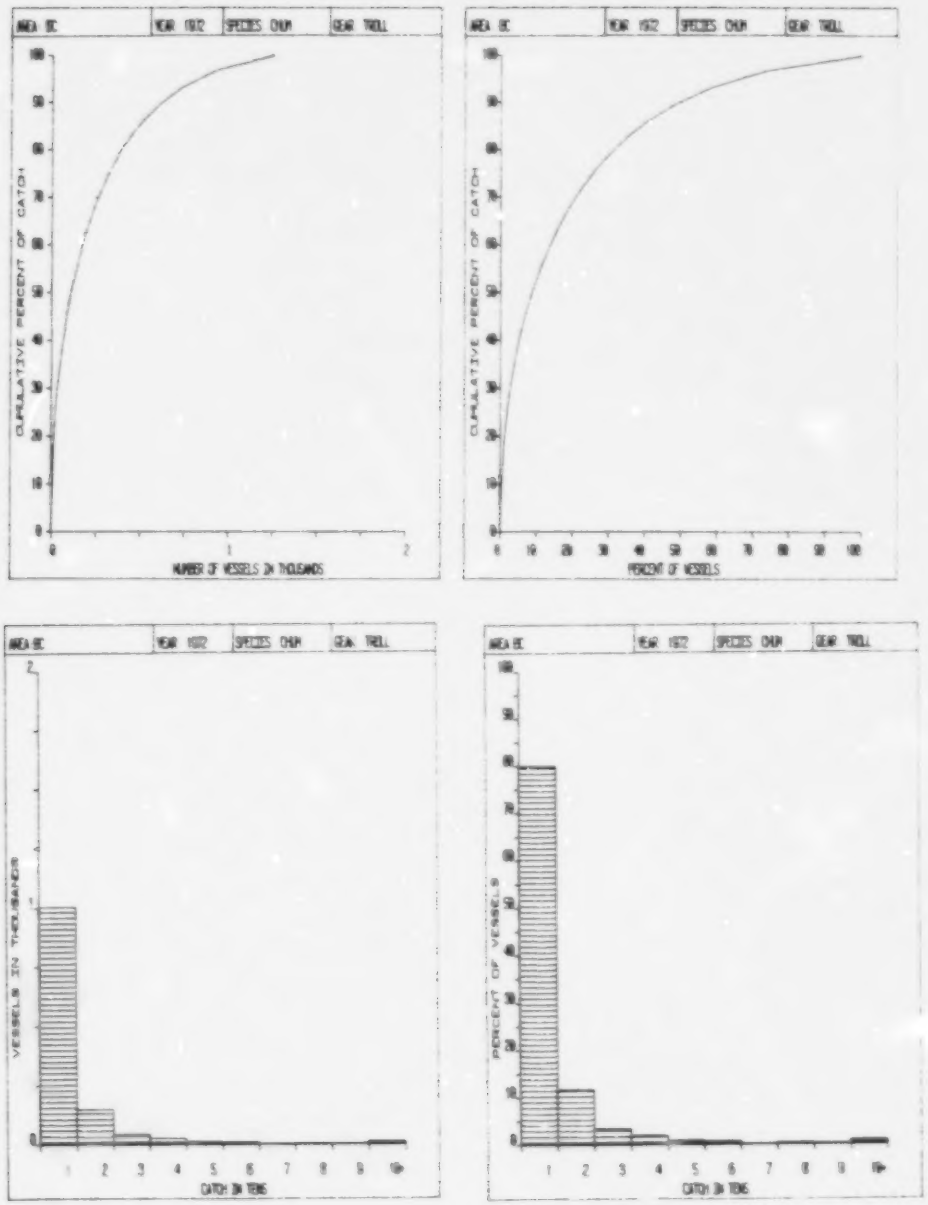

Fig. C6. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1972.

Fig. C7. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1973.

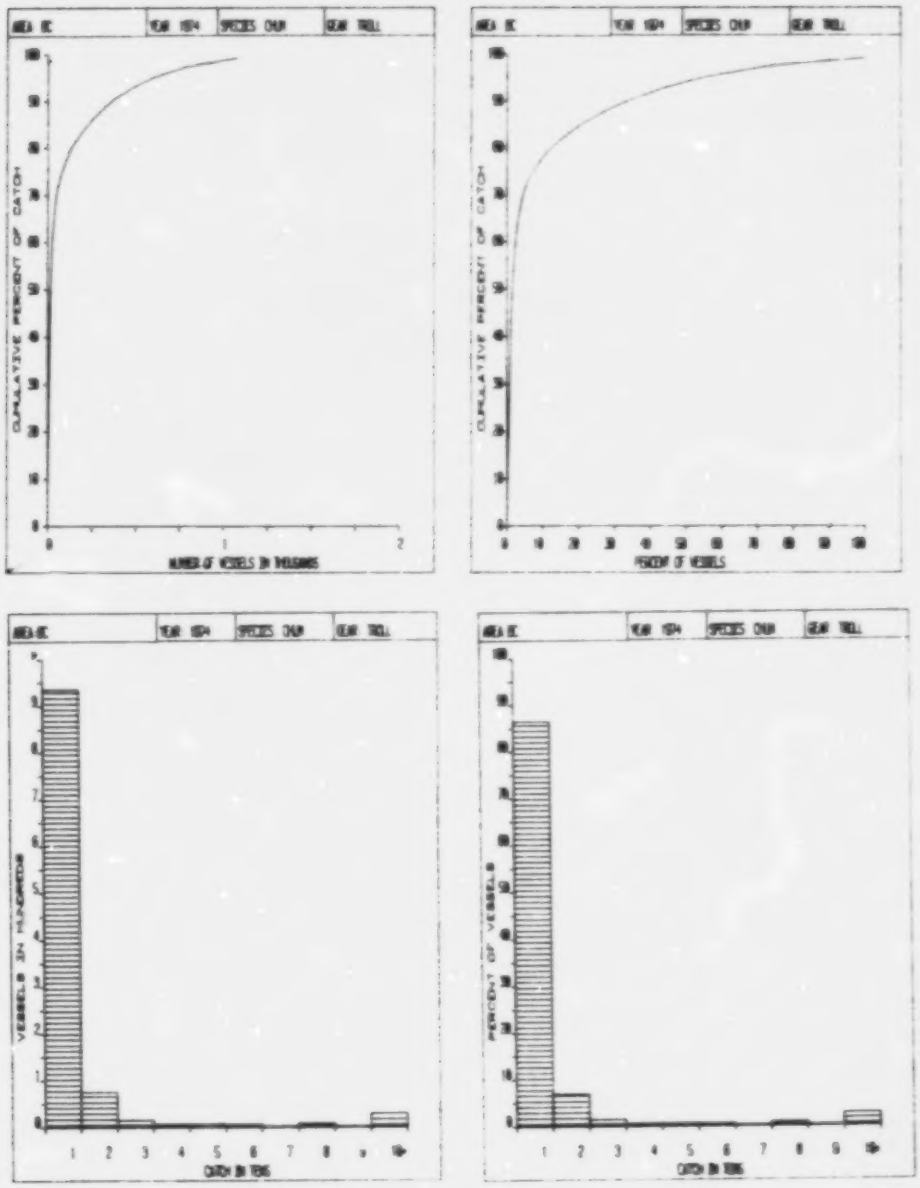

Fig. C8. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1974.

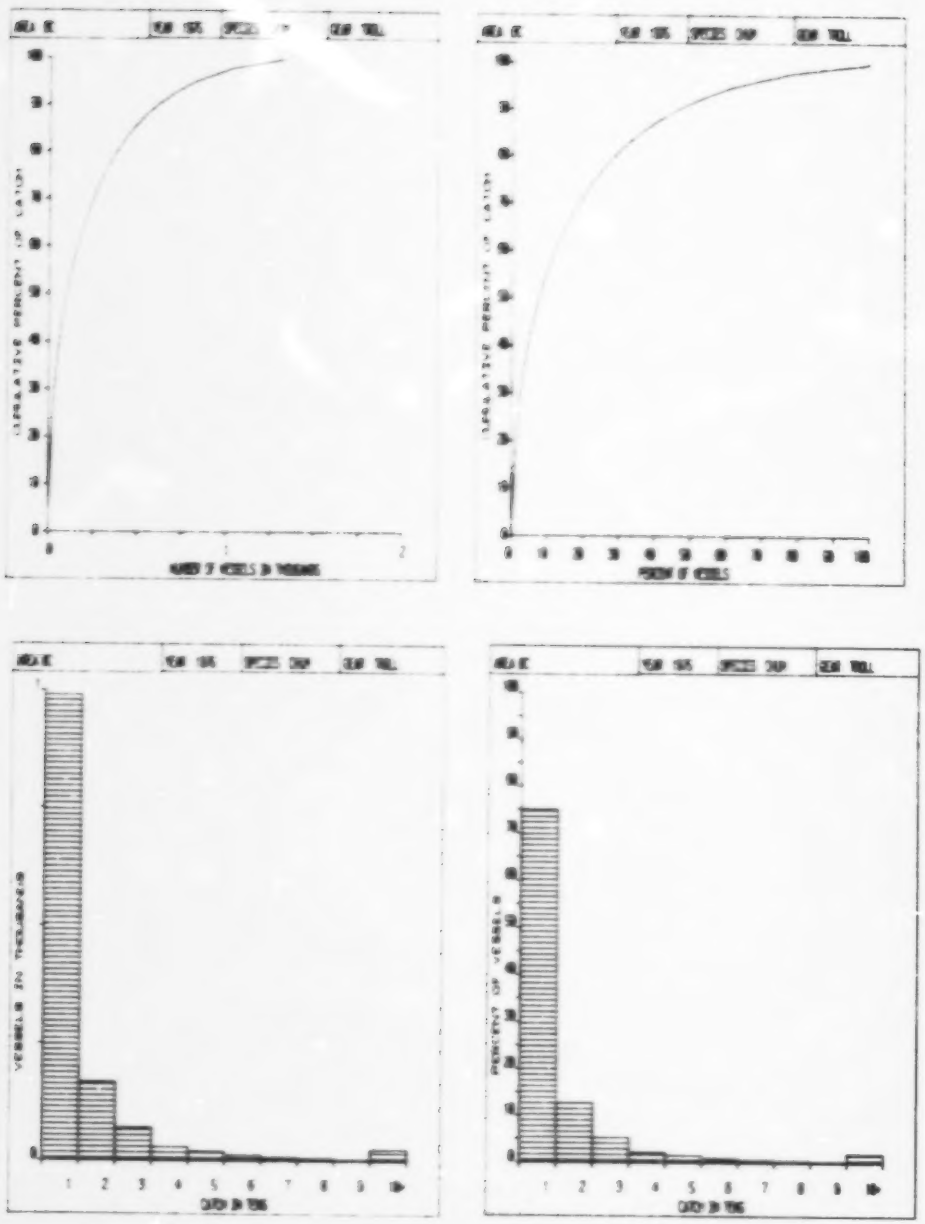

Fig. C9. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1975.

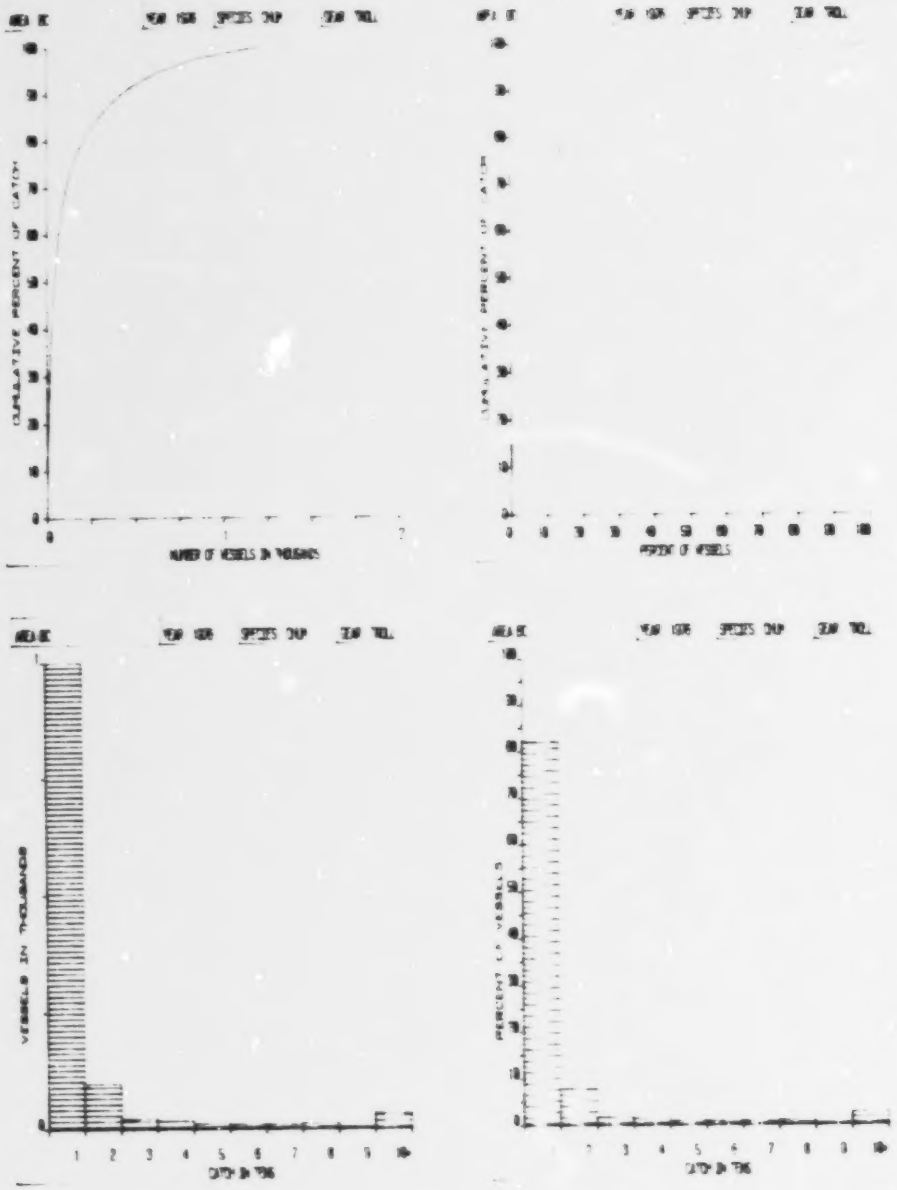

Fig. C10. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1976.

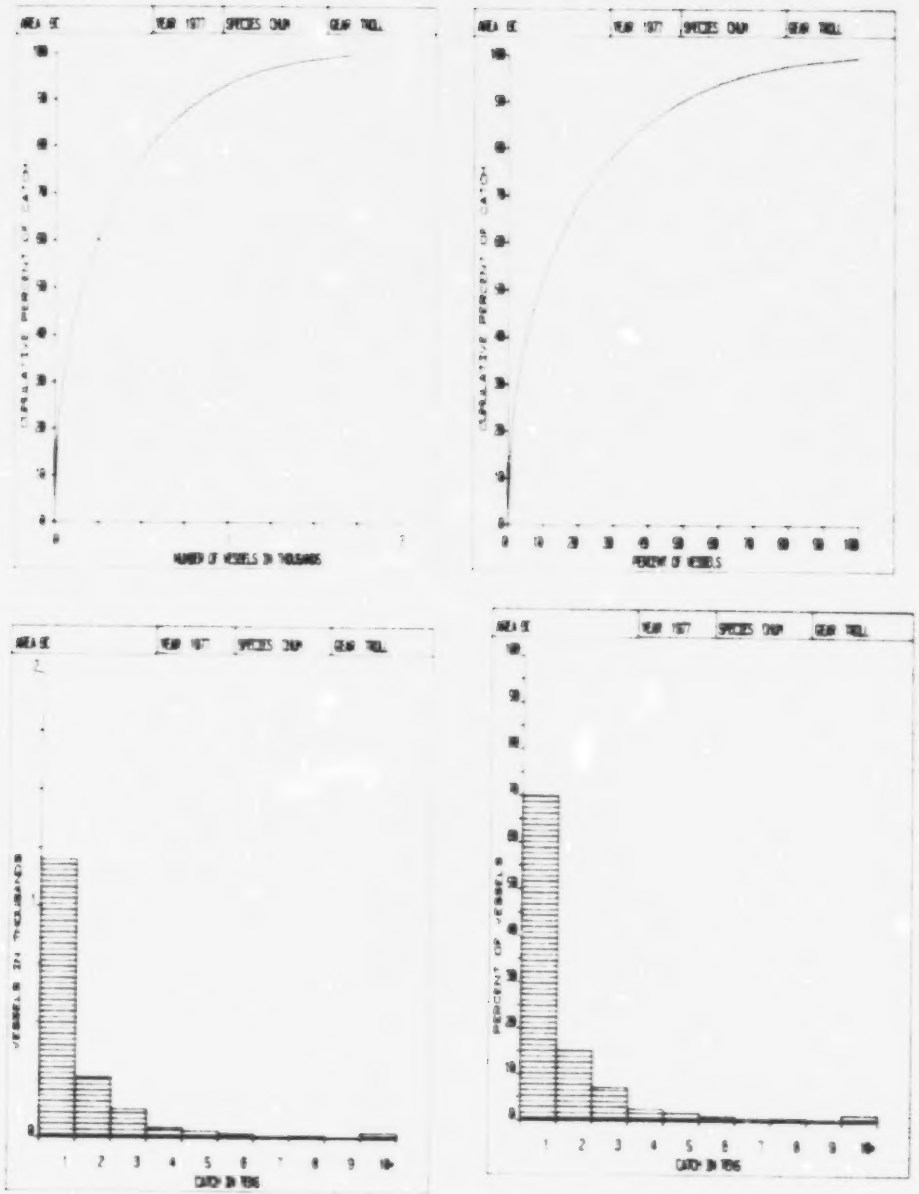

Fig. C11. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1977.

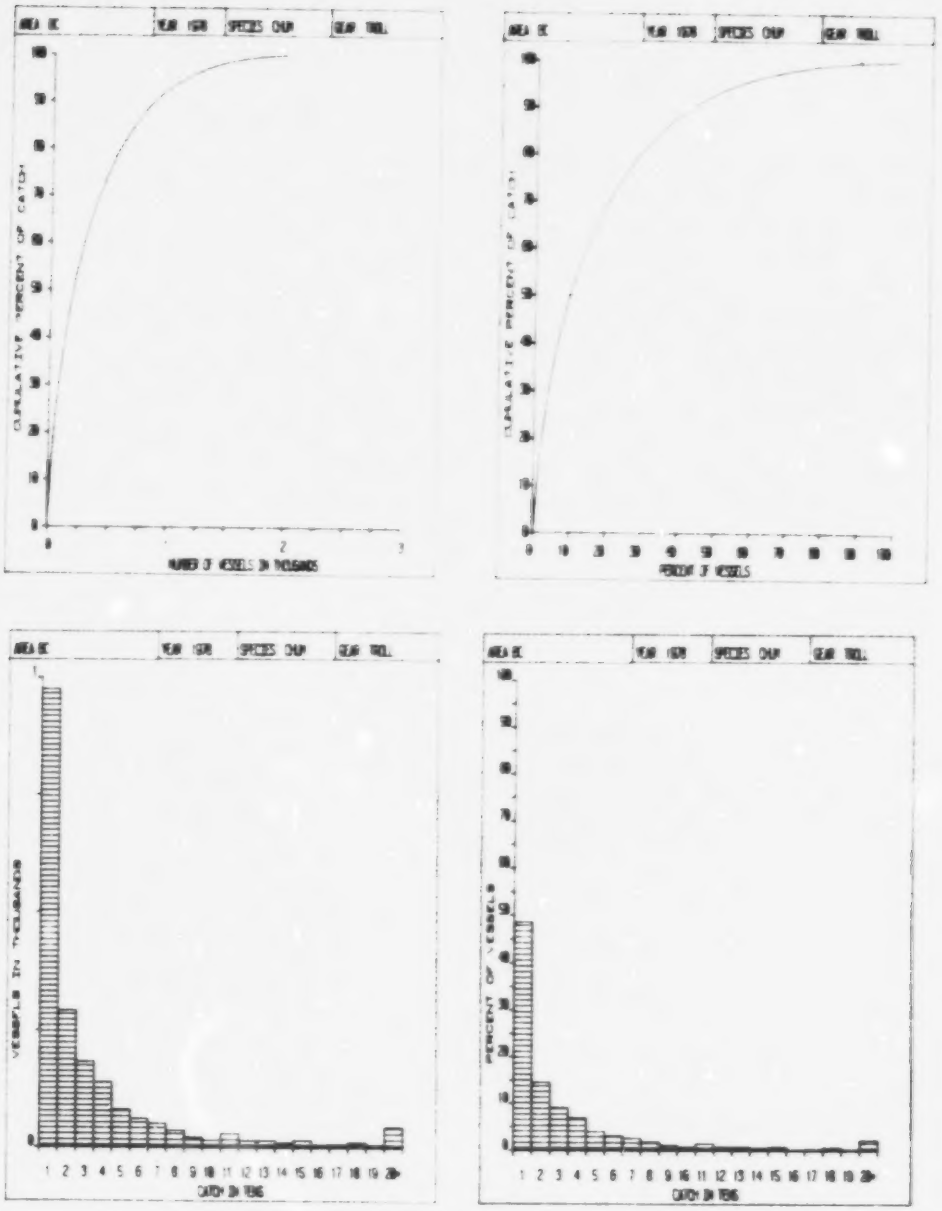

Fig. C12. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1978.

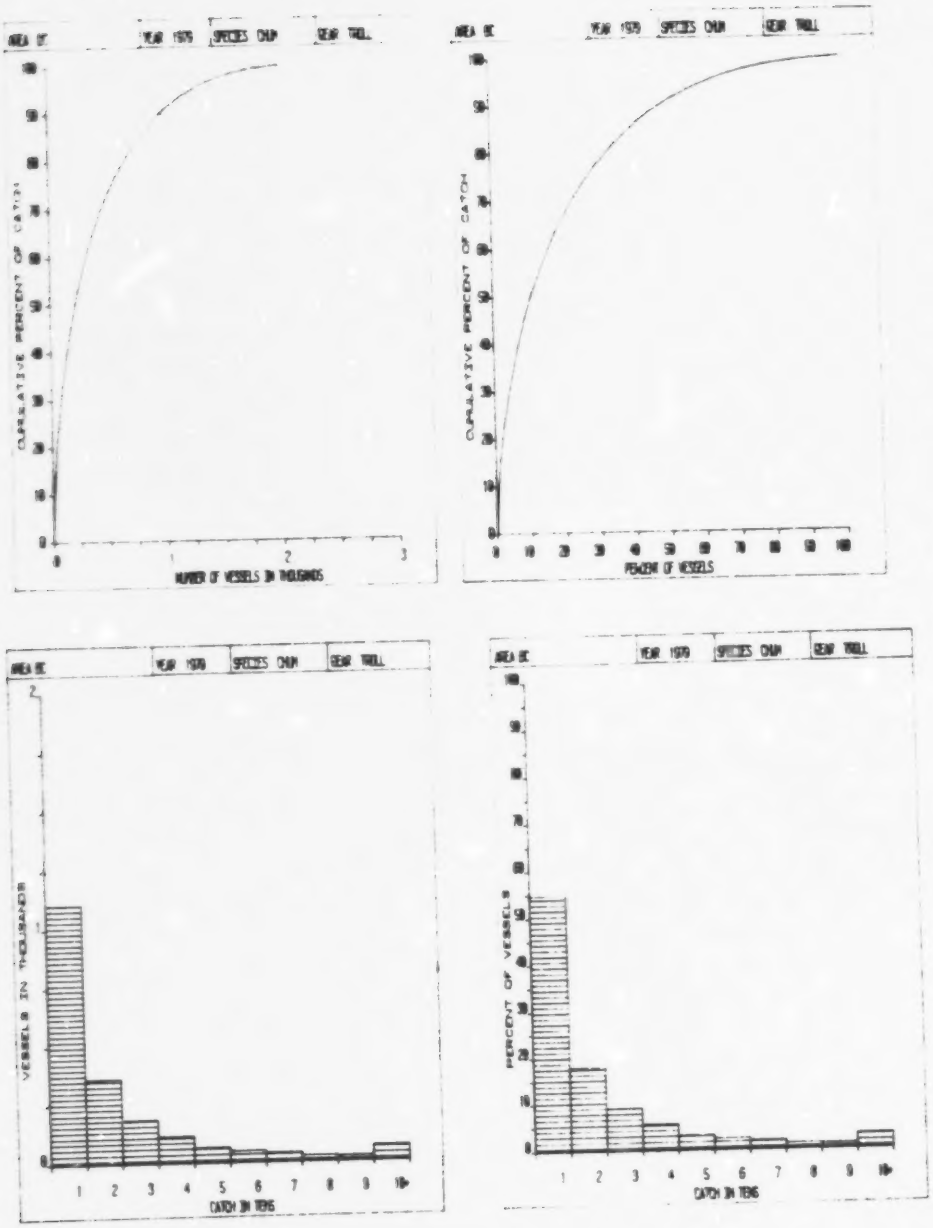

Fig. C13. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1979.

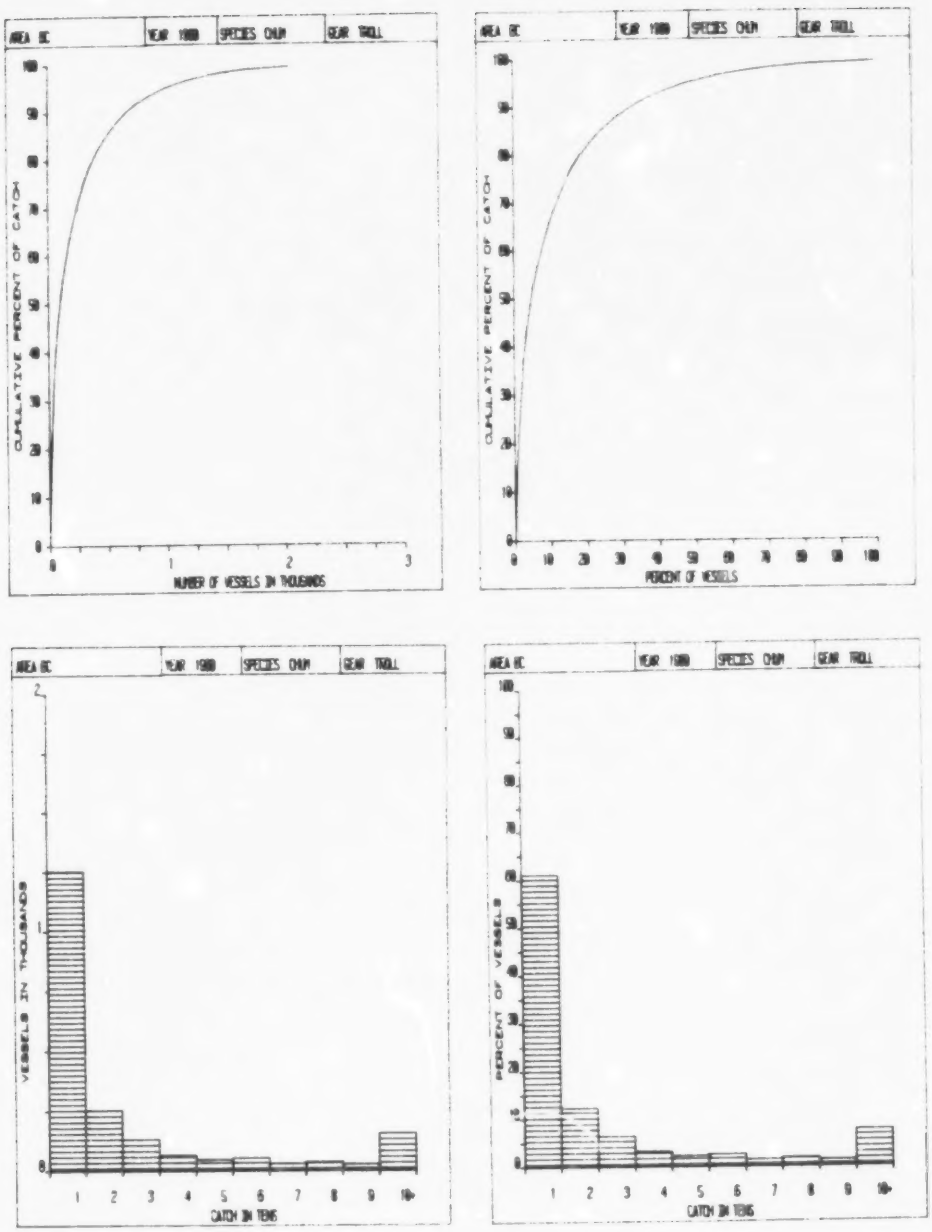

Fig. C14. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1980.

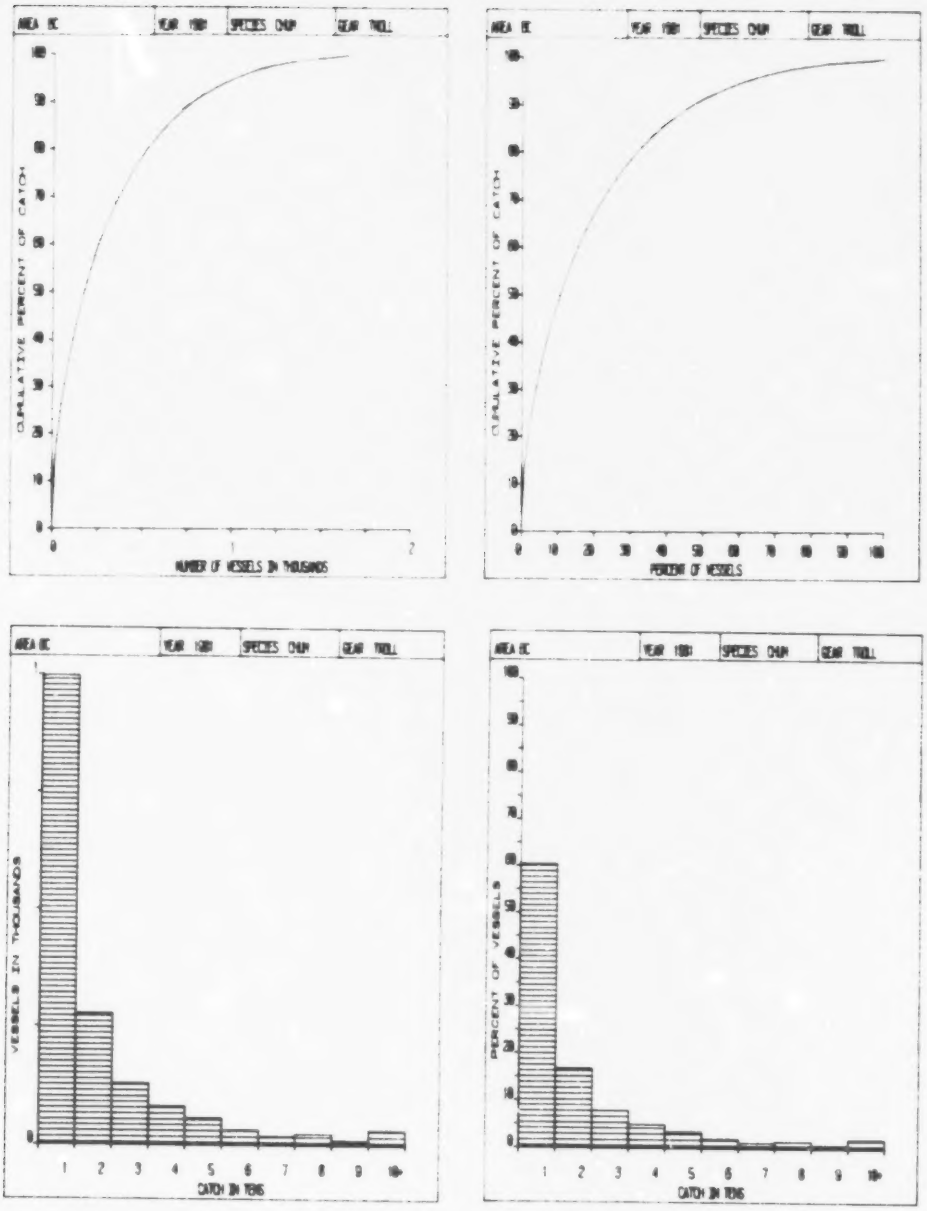

Fig. C15. Cumulative percent and frequency of catch of chum salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1981.